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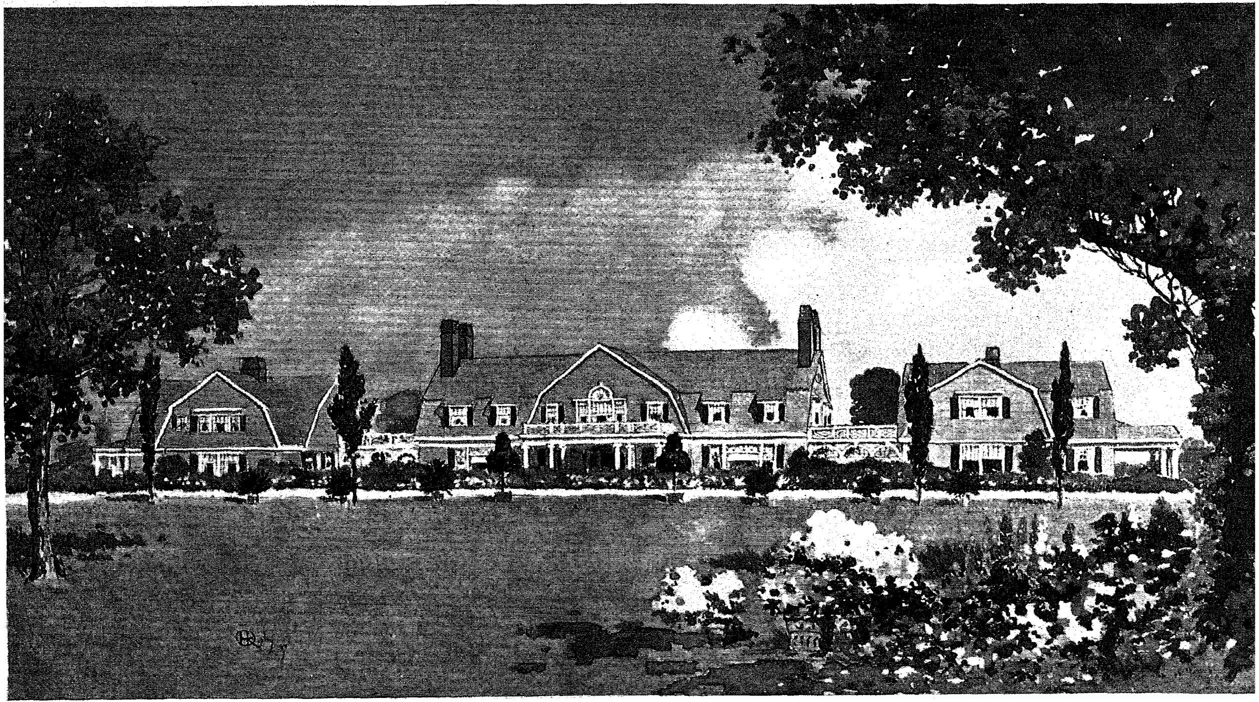

"DREAMWOLD," THE FARM OF THOMAS W. LAWSON, ESQ., SCITUATE, MASS.
Coolidge & Carlson, Architects, Boston, Mass. For plan, see next succeeding plate.

Cyclopedia
of
Architecture, Carpentry and Building

A General Reference Work

ON ARCHITECTURE, CARPENTRY, BUILDING, SUPERINTENDENCE,
CONTRACTS, SPECIFICATIONS, BUILDING LAW, STAIR-BUILDING,
ESTIMATING, MASONRY, REINFORCED CONCRETE, STEEL
CONSTRUCTION, ARCHITECTURAL DRAWING, SHEET
METAL WORK, HEATING, VENTILATING, ETC.

Prepared by a Staff of

ARCHITECTS, BUILDERS, AND EXPERTS OF THE HIGHEST
PROFESSIONAL STANDING

Illustrated with over Three Thousand Engravings

TEN VOLUMES

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AMERICAN TECHNICAL SOCIETY
1908

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THE editors have freely consulted the standard technical literature of America and Europe in the preparation of these volumes. They desire to express their indebtedness particularly to the following eminent authorities whose well-known works should be in the library of everyone connected with building.

Grateful acknowledgment is here made also for the invaluable co-operation of the foremost architects, engineers, and builders in making these volumes thoroughly representative of the very best and latest practice in the design and construction of buildings; also for the valuable drawings and data, suggestions, criticisms, and other courtesies.

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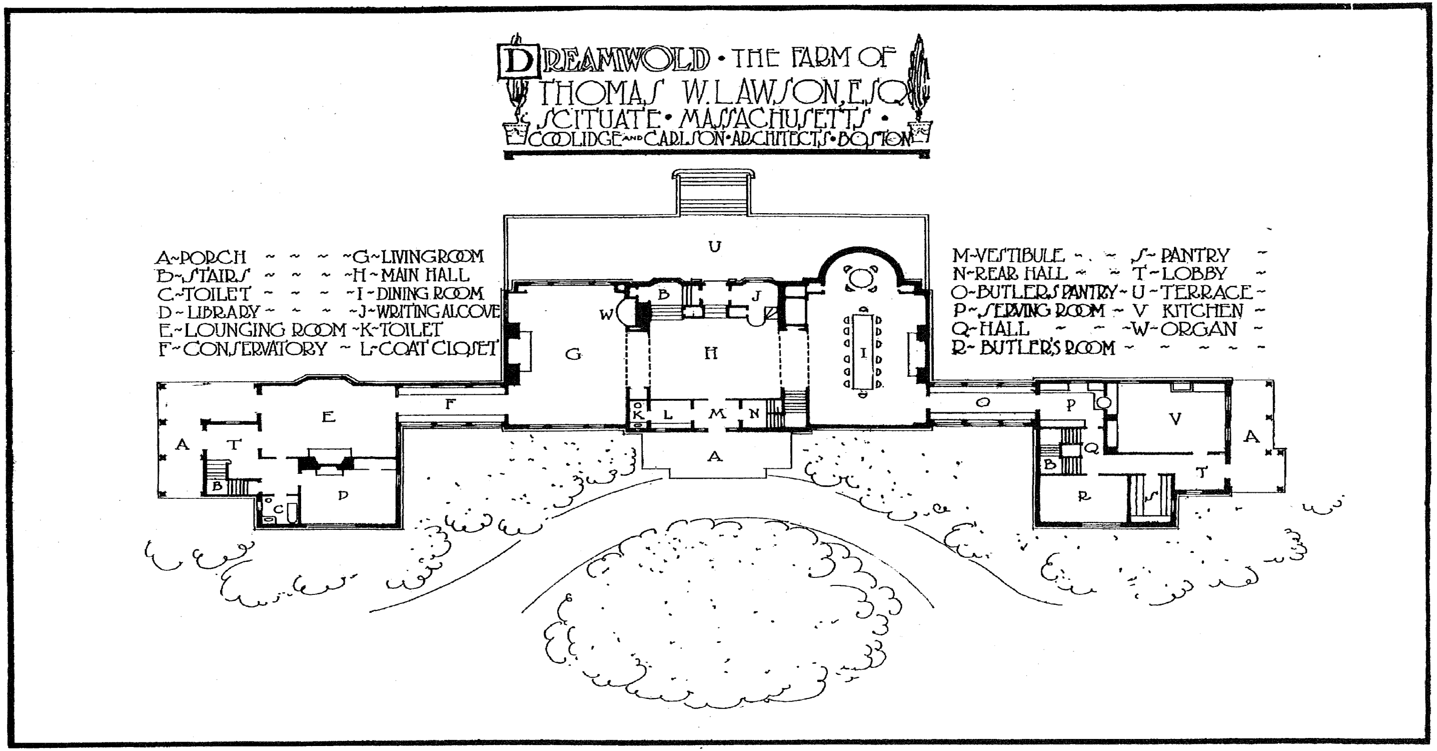
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COOLIDGE AND CARLSON · ARCHITECTS · BOSTON
A~PORCH ~ ~ ~ ~G~LIVINGROOM
B~STAIRS ~ ~ ~ ~H~MAIN HALL
C~TOILET ~ ~ ~ ~I~DINING ROOM
D~LIBRARY ~ ~ ~ ~J~WRITING ALCOVE
E~LOUNGING ROOM ~K~TOILET
F~CONSERVATORY ~ L~COAT CLOSET
M~VESTIBULE ~ ~ S~PANTRY ~
N~REAR HALL ~ ~ T~LOBBY ~
O~BUTLERS PANTRY~ U~TERRACE~
P~SERVING ROOM ~ V KITCHEN ~
Q~HALL ~ ~ ~W~ORGAN ~
R~BUTLER'S ROOM ~ ~ ~ ~ ~
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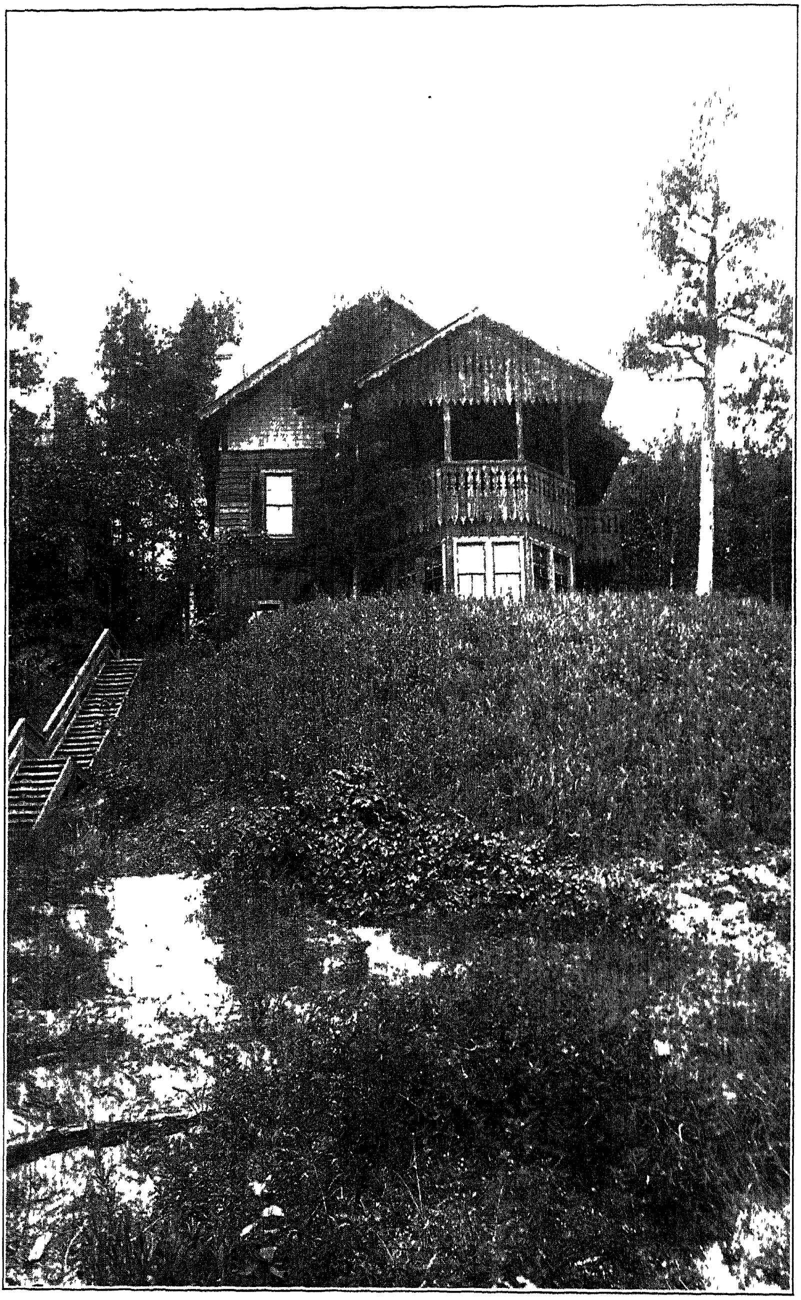
PLAN OF "DREAMWOLD," THE FARM OF THOMAS W. LAWSON, ESQ., SCITUATE, MASS.

Coolidge & Carlson, Architects, Boston, Mass.

For Exterior View, Reproduced in Color, See Frontispiece in this Volume.

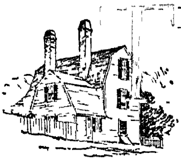


SUMMER COTTAGE FOR THE MISSES DUMMER, AT HARBOR POINT, MICH.

Pond & Pond, Architects, Chicago.

Built in 1903. Cost, $7,300. Plans and Interior are Shown on Pages 86 and 90.

Foreword



THE rapid evolution of constructive methods in recent years, as illustrated in the use of steel and concrete, and the increased size and complexity of buildings, has created the necessity for an authority which shall embody accumulated experience and approved practice along a variety of correlated lines. The Cyclopedia of Architecture, Carpentry, and Building is designed to fill this acknowledged need.

¶ There is no industry that compares with Building in the close interdependence of its subsidiary trades. The Architect, for example, who knows nothing of Steel or Concrete construction is to-day as much out of place on important work as the Contractor who cannot make intelligent estimates, or who understands nothing of his legal rights and responsibilities. A carpenter must now know something of Masonry, Electric Wiring, and, in fact, all other trades employed in the erection of a building; and the same is true of all the craftsmen whose handiwork will enter into the completed structure.

¶ Neither pains nor expense have been spared to make the present work the most comprehensive and authoritative on the subject of Building and its allied industries. The aim has been, not merely to create a work which will appeal to the trained expert, but one that will commend itself also to the beginner and the self-taught, practical man by giving him a working knowledge of the principles and methods, not only of his own particular trade, but of all other branches of the Building Industry as well. The various sections have been prepared especially for home study, each written by an acknowledged authority on the subject. The arrangement of matter is such as to carry the student forward by easy stages. Series of review questions are inserted in each volume, enabling the reader to test his knowledge and make it a permanent possession. The illustrations have been selected with unusual care to elucidate the text.

¶ The work will be found to cover many important topics on which little information has heretofore been available. This is especially apparent in such sections as those on Steel, Concrete, and Reinforced Concrete Construction; Building Superintendence; Estimating; Contracts and Specifications, including the principles and methods of awarding and executing Government contracts; and Building Law.

¶ The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy working man.

¶ In conclusion, grateful acknowledgment is due the staff of authors and collaborators, without whose hearty co-operation this work would have been impossible.

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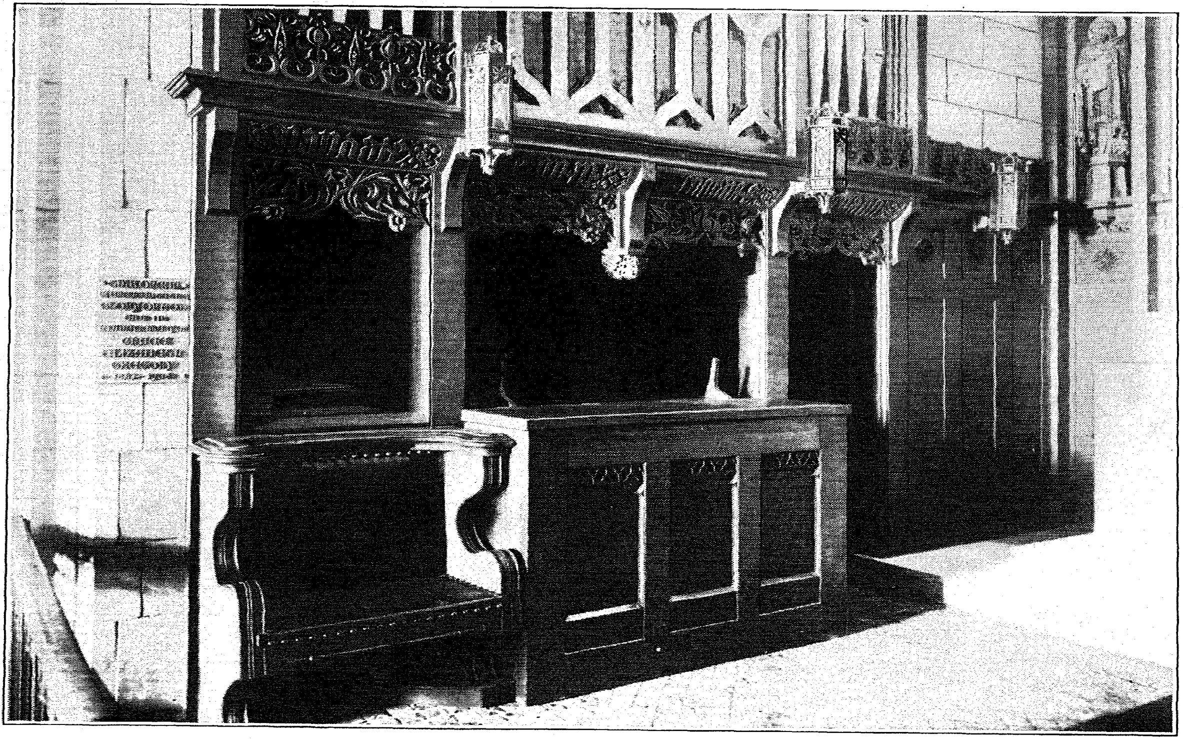

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Carved Quarter-Sawed Oak of Lower Portion of Organ Case. Oak is Stained and Waxed. For Exterior and Interior, See Vol. I, Page 10, and Vol. II, Page 74.

CARPENTRY.

PART I.

The art of Carpentry has been practiced by men in all ages and in all lands, and is likely to continue as long as there is any timber out of which dwellings and utensils can be made. Under different conditions and in widely separated parts of the world there have been developed various methods of doing the same work, and men have attained to various degrees of proficiency in the handling of tools, and in the making of the tools themselves. From the time when the primitive man built himself a hut out of brush-wood and mud, to the present day, when we live in comfortable dwellings built of seasoned timber, there has been constant progress and development, so that there has accumulated a vast amount of experience to which we are the fortunate heirs.

The carpenter has always found his material at hand, provided by nature, and needing only to be cut down and shaped to suit his purposes. In those places where wood did not grow near by, there were no carpenters, but instead, workers in stone or clay.

A knowledge of the characteristics of wood, which plays so important a part in all our lives and which is so plentiful in our own land, is likely to prove of advantage to anyone, and is an absolute necessity to a carpenter. Let us therefore, first of all, devote some space to a consideration of timber, both in its natural state, and in its commercial form as prepared for the market.

NATURAL TIMBER.

Wood is one of the most common of building materials, and may be seen everywhere in its natural state as well as in various forms prepared for use. It is all taken originally from some kind of tree or shrub, and a consideration of the manner of growth of the tree itself will explain many peculiarities and defects of timber in its commercial form.

Classes of Trees. The trees from which most of our timber is taken are of two kinds: the "broad-leaved," such as the oak, poplar, and maple, and the "conifer" or "needle-leaved," such as the pines, the fir, and the cedar. In the South some timber is used which comes from another class of trees, of which the palms are the most common representatives; the use of this timber, however, is very limited. In general, it may be said that the wood from the broad-leaved trees is "hardwood" while that from the conifers is "softwood," but this rule does not hold true in all cases.

Manner of Growth. There is a marked difference between the three classes of trees mentioned above in regard to their manner of growth. While the members of the third class, the palms and others, grow only at the top, and have the same diameter of trunk after years of development, the members of the other two classes increase in size of trunk as well as in height. Each year a new layer of wood is formed on the outside of the trunk and branches, underneath the bark, and the age of the tree may usually be determined by counting the number of layers. In the center of the tree there is always a small whitish part, called the "pith," about which the wood itself is arranged in concentric rings, as shown in Fig. 1, in which A is the pith, B the woody part of the tree, and C the bark. The arrangement of the wood in concentric rings is due to the fact that it was formed gradually, one layer being added each year, and for this reason the rings or layers are called "annual rings."

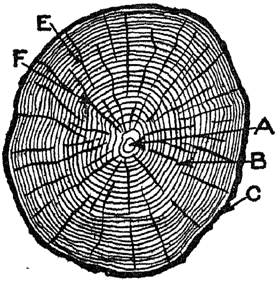

Fig. 1. Section of Log.

The wood nearest the center, or pith, is considerably harder and darker in color than that which is on the outside nearer the bark; it is called the "heartwood" to distinguish it from the other which is called the "sapwood." Only the heartwood should be used for building work. The reason why it is harder than the sapwood is that it is older and has been compressed more and more each year as the tree has increased in size, and the pores have gradually become filled up. The sapwood is soft and of lighter color and shows that it has been recently formed. The time required to transform the wood from sapwood into heartwood varies from nine to thirty-five years, according to the nature of the tree, and those trees which perform this hardening in the shortest time are usually the most durable. The sap rises in the spring from the roots of the tree to the branches and twigs, forming the leaves, and in the autumn it flows back again between the wood and the bark. Thus a new annual ring is formed.

The width of the annual rings varies from $\frac{1}{50}$ inch to $\frac{1}{8}$ inch according to the character of the tree and the position of the ring. In general it may be said that the widest rings are found nearest the center, or pith, and that they grow regularly narrower as they approach the bark. Also they are wider at the bottom of the trunk than at the top. The rings are very seldom circular or regular in form, but follow the contour of the tree trunk.

In addition to the annual rings there may be seen on the cross-section of any log other lines which run from the center toward the bark at right angles to the annual rings. These are called the "medullary" rays. Usually they do not extend to the bark, but alternate with others which start at the bark and run inward toward the center but are lost before they reach the pith. This is shown at E and F in Fig. 1.

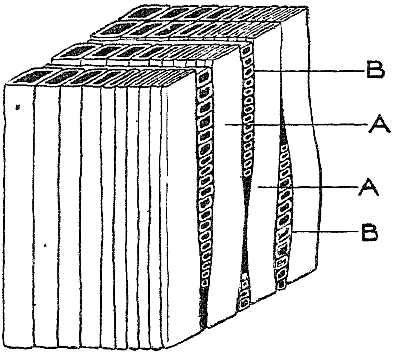

Fig. 2. Arrangement of Fibers.

Details of Structure. The two above-mentioned classes of wood differ considerably in their structure, that of the conifers being very simple and regular in arrangement, while that of the broad-leaved trees is complex and irregular. The wood is made up of bundles of fibers or long tubes, parallel to the stem of the tree, which are crossed by other fibers that form the medullary rays, passing from the pith to the bark and binding the whole together. Besides these there are resin ducts and other fibers scattered through the trunk of the tree. The arrangement is shown in Fig. 2. A A are the long fibers, and B B the pith or medullary fibers. Of course these are so small that the individual fibers cannot be distinguished without the aid of a powerful microscope. In pine more than fifteen thousand pith rays occur on a square inch of section.

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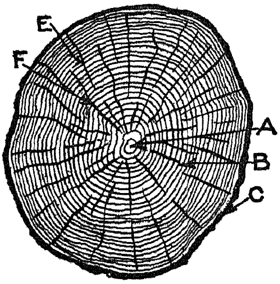


Fig. 1. Section of Log.

The wood nearest the center, or pith, is considerably harder and darker in color than that which is on the outside nearer the bark; it is called the "heartwood" to distinguish it from the other which is called the "sapwood." Only the heartwood should be used for building work. The reason why it is harder than the sapwood is that it is older and has been compressed more and more each year as the tree has increased in size, and the pores have gradually become filled up. The sapwood is soft and of lighter color and shows that it has been recently formed. The time required to transform the wood from sapwood into heartwood varies from nine to thirty-five years, according to the nature of the tree, and those trees which perform this hardening in the shortest time are usually the most durable. The sap rises in the spring from the roots of the tree to the branches and twigs, forming the leaves, and in the autumn it flows back again between the wood and the bark. Thus a new annual ring is formed.

The width of the annual rings varies from $\frac{1}{50}$ inch to $\frac{1}{8}$ inch according to the character of the tree and the position of the ring. In general it may be said that the widest rings are found nearest the center, or pith, and that they grow regularly narrower as they approach the bark. Also they are wider at the bottom of the trunk than at the top. The rings are very seldom circular or regular in form, but follow the contour of the tree trunk.

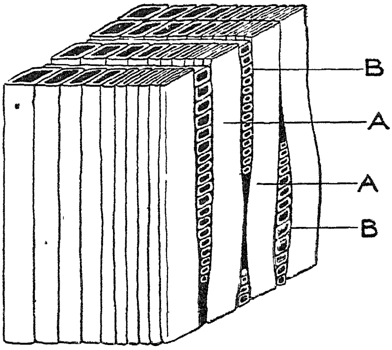


Fig. 2. Arrangement of Fibers.

In addition to the annual rings there may be seen on the cross-section of any log other lines which run from the center toward the bark at right angles to the annual rings. These are called the "medullary" rays. Usually they do not extend to the bark, but alternate with others which start at the bark and run inward toward the center but are lost before they reach the pith. This is shown at E and F in Fig. 1.

Details of Structure. The two above-mentioned classes of wood differ considerably in their structure, that of the conifers being very simple and regular in arrangement, while that of the broad-leaved trees is complex and irregular. The wood is made up of bundles of fibers or long tubes, parallel to the stem of the tree, which are crossed by other fibers that form the medullary rays, passing from the pith to the bark and binding the whole together. Besides these there are resin ducts and other fibers scattered through the trunk of the tree. The arrangement is shown in Fig. 2. A A are the long fibers, and B B the pith or medullary fibers. Of course these are so small that the individual fibers cannot be distinguished without the aid of a powerful microscope. In pine more than fifteen thousand pith rays occur on a square inch of section.

Grain of Wood. Woods are commonly spoken of as "fine-grained," "coarse-grained," "cross-grained," or "straight-grained." The wood is said to be fine-grained when the annual rings are relatively narrow, and coarse-grained when these rings are wide. Fine-grained wood can be made to take a high polish while with coarse-grained wood, in general, this is not possible. When the fibers are straight, and parallel to the direction of the trunk of the tree, the wood is said to be straight-grained, but if they are distorted or if they are twisted so as to be spiral in form, not growing straight up but following around the trunk of the tree, the wood is said to be cross-grained. In Fig. 3 are shown three pieces of timber of which A is absolutely cross-grained, B is partially cross-grained and C is straight-grained.

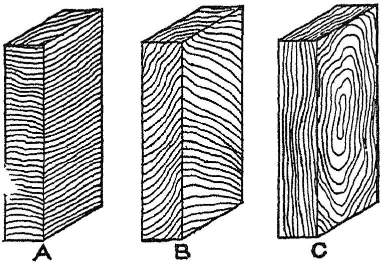


Fig. 3. Grain of Wood.

Defects. Most of the defects which render timber unsuitable for building are due to irregularities in the growth of the tree from which the timber was taken. These defects are known by various names, such as "Heartshakes," "Windshakes," "Starshakes," and "Knots." Other defects are due to deterioration of the timber after it has been in place for some time or even before the tree has been felled, among which are "Dry Rot" and "Wet Rot." The defects of the first class are defects of structure — those of the second class are defects of the material itself.

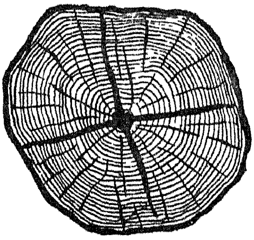


Fig. 4. Heartshake.

Heartshake. Fig. 4 shows what is known as a heartshake. There is first a small cavity at the heart of the tree caused by decay, and flaws or cracks extend from it out toward the bark. The heartshake is most often found in those trees which are old, rather than in young, vigorous saplings; it is especially to be feared in hemlock timber.

Windshake. Fig. 5 shows what is known as a windshake or cupshake. This is caused by a separation of the annual rings one from another so that a crack is formed in the body of the tree; this crack may extend for a considerable distance up the trunk. This defect is said to be caused by the expansion of the sapwood, and it is also claimed that it is caused by the wrenching to which the tree is subjected by high winds. Windshakes are very often found in pine timber.

A *starshake* is very much like a heartshake, the chief difference being that the starshake cracks extend right across the center of the trunk without any appearance of decay at that point.

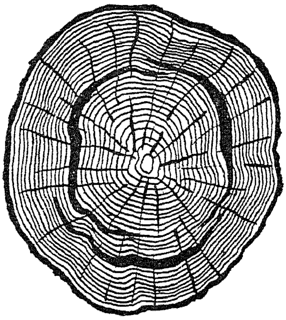


Fig 5 Windshake.

Dry rot in timber is caused by a fungus growth, and takes place most readily when the timber is in such a position that it is alternately wet and dry. If wood is kept perfectly dry, or, on the other hand, is kept constantly under water, it will last indefinitely without any sign of rot. For this reason piles should always be cut off below the water level. Decay takes place very rapidly when the wood is in a confined position, as when buried in a brick wall, so that the gases cannot escape. It is also hastened by warmth, and is much more common in the South than in the northern states. Decay may be prevented by introducing into the timber certain salts, such as the salts of mercury. It may also be prevented by heating the wood to a temperature above 150 degrees Fahrenheit and maintaining that temperature. All wood should be perfectly seasoned before being painted, and good ventilation should always be provided for. Wood should be especially protected whenever in contact with masonry from which it may absorb moisture.

Wet rot is a form of decay which takes place in the growing tree. It is caused by the tree becoming saturated with water, as in a swamp or bog, and it may be communicated from one piece of timber to another by contact.

Warping in timber is the result of the evaporation or drying out of the water which is held in the cell walls of the wood in its natural state, and the consequent shrinkage of the piece. If timber were perfectly regular in structure, so that the shrinkage would be the same in every part, there would be no warping; but wood is made up of a large number of fibers, the walls of which are of different thickness in different parts of the tree or log, so that in drying one part shrinks much more than another. Since the wood is rigid, one part cannot shrink or swell without changing the shape of the whole piece, because the block as a whole must adjust itself to the new conditions; consequently the timber warps.

In Fig. 6, if the fibers in the top portion of the piece near the face *a b e* happen to have, on the average, thicker walls than those

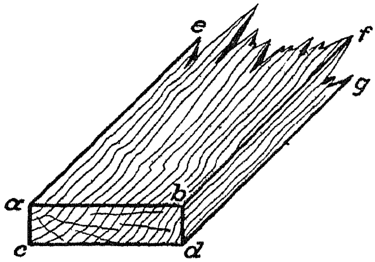


Fig. 6.

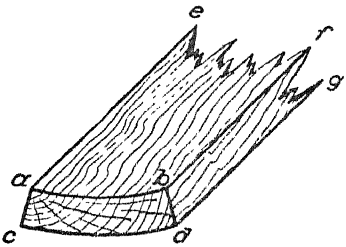


Fig. 7.

in the bottom portion, near the face *c d g*, the top part will shrink more than the bottom; the distance *a b*, originally equal to the distance *c d*, becomes smaller and the shape of the whole piece changes, as shown in Fig. 7.

The only way in which warping can be prevented is to have the timber thoroughly dried out before it is used. After it is once thoroughly seasoned it will not warp unless it is allowed to absorb more moisture. All wood that is to be used for fine work, where any warping after it is in place will spoil the appearance of the whole job, must be so seasoned, either in the open air or in a specially prepared kiln.

The wood of the "conifers," which is very regular in its structure, shrinks more evenly and warps less than the wood of the broad-leaved trees with its more complex and irregular structure. Sapwood, also, as a rule shrinks more than does heartwood.

Checks also are due to the uneven shrinkage of timber. In any log there is a chance for the wood to shrink in two directions — along the radial lines following the direction of the medullary rays, and around the circumference of the log, following the direction of the annual rings. If the wood shrinks in both directions at the same rate, the only result will be a decrease in the volume of the log, but if it shrinks more rapidly in one of these directions than it does in the other, the log must crack around the outside as shown in Fig. 8. This cracking is called "checking," and is likely to take place. In timber which has been prepared for the market it shows itself in the form of cracks which extend along the faces of solid square timbers and boards, and seriously impairs the strength. Fig. 9 shows checks in a square post or column.

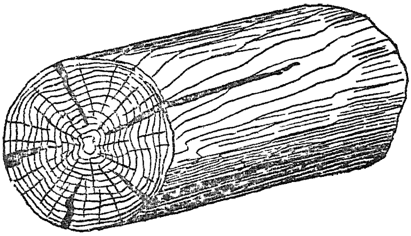


Fig. 8. Cracks Caused by Shrinkage.

Knots are very common in all timber. They are formed at the junction of the main tree trunk and a branch or limb. At such points the fibers in the main trunk, near the place where the branch comes in, do not follow straight along up the trunk, but are turned aside and follow along the branch as shown in Fig. 10. Frequently a branch may be broken off near the trunk while the tree is still young, and the tree continue to grow. The trunk will increase in size until the end of the branch, which was left behind buried in the main trunk, is entirely covered up. Meanwhile the end of the branch dies and a knot is formed. This bit of dead wood has no connection with the living wood about it. In time it works loose, and when the tree is sawed up into boards the knot may drop out. A knot does not seriously impair a piece subjected to a compressive stress, so long as it remains in place, but it greatly weakens a piece subjected to tension. A knot always spoils the appearance of any wood which is to be polished.

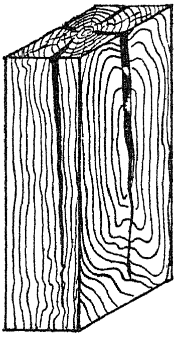


Fig. 9. Checks in Square Post.

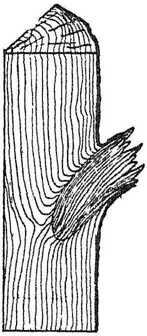


Fig. 10. Knots.

TIMBER IN ITS COMMERCIAL FORM.

Conversion of Timber. Timber may be found in lumber yards in certain shapes ready for use, having been cut from the logs and relieved of the outside covering, or bark. There are various methods of cutting up the logs to form boards, planks and heavy timbers. If the log is to be squared off to form but one heavy beam, a good rule to follow is to divide the diameter into three equal parts, and draw perpendiculars to the diameter at these points, one on each side of the diameter, as shown at A and B in Fig. 11. The points *c* and *d* in which these perpendiculars cut the circumference of the tree trunk, together with the points *e* and *f* in which the chosen diameter cuts the circumference of the tree trunk, will be the four corners of the timber. The lines joining these points will give an outline of the timber. This will be found to be the largest and best timber which can be cut from the log.

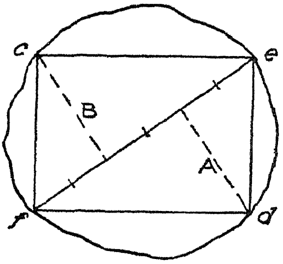


Fig. 11. Squaring off a Log.

Another good rule is to divide the diameter of the log into *four* equal parts and proceed in the same way as described above, using the outside quarter points on the diameter as shown in Fig. 12. This method will give a stiffer beam but it will not be so strong.

In Fig. 13 are shown several different methods of cutting planks from a log. First it is divided into quarters, and the planks are cut out as shown. The method shown at A, called "quarter sawing," is the best. All the planks are cut radiating from the center and there will be no splitting and warping. A fairly good method is that shown at B, where the planks are pretty nearly in radial lines and may be much more easily cut out than can those shown at A. The method shown at C is a common one and leads to fairly good results, although only the plank in the center is on a radial line. It is practically as good a method as that shown at B and is much more simple. The method shown at D is not so good as the others; planks cut in this way being very liable to warp and twist. If the silver grain, caused by the cutting of the medullary rays, is desired, the planks should be cut as at A or B.

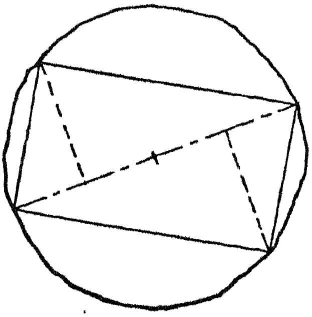


Fig. 12. Squaring off a Log.

Planks may sometimes be simply sliced from the log as shown in Fig. 14, without first dividing it into quarters. This is the worst possible way to cut them, as the natural tendency of the timber to shrink causes the planks to curl up as shown in Fig. 15. It is almost impossible to flatten them out again and they cannot be used as they are.

VARIETIES OF TIMBER.

There are a great many different kinds of timber growing in the United States, and a considerable quantity is imported from other countries. Each variety possesses certain characteristics which render it especially suitable for use in one part of the building, while the same peculiarities of growth or of texture may unfit it for use in another place.

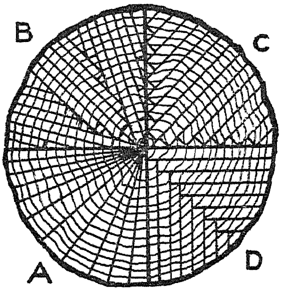


Fig. 13. Quarter Sawing.

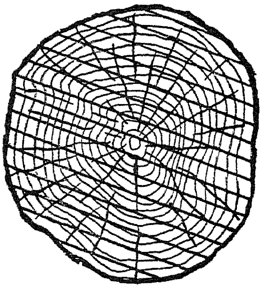


Fig. 14. Straight Sawing.

For timbers which are to be partly buried in the ground a wood is required which is able to withstand the deteriorating effects of contact with the earth; and for this purpose chestnut, white cedar, cypress, redwood or locust may be used.

For light framing we need a cheap, light wood free from structural defects such as knots and shakes, and which can be obtained in fairly long, straight pieces. Spruce, yellow pine, white pine and hemlock all satisfy these requirements fairly well, spruce being perhaps a little better than the others, and at any rate more popular.

For heavy framing, such as wooden trusses, girders and posts, we require a strong timber and one which can be obtained in large, long pieces. Georgia pine, Oregon pine and white oak may all be used for such work, and also Norway pine and Canadian red pine.

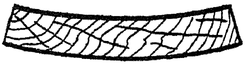


Fig. 15.

A wood which is easily worked and which will also withstand the effects of the weather is needed for the outside finish; for this we select white pine and also cypress and redwood. The same woods are used for shingles, clapboards and siding, with the addition of cedar for shingles, and sometimes Oregon pine and spruce for siding.

For the interior finish is chosen a wood which will make a pleasing appearance, and which will take a polish; while for floors, hardness and resistance to wear are the further requirements. For floors, oak, hard pine, and maple are good; and for the rest of the interior finish, white pine, cypress and redwood, or any of the hard woods such as ash, butternut, cherry and mahogany, may be selected.

Some of the more important varieties of timber used in carpentry will now be mentioned, and a brief description of each kind given to convey an idea of its characteristics and the part of the country from which it comes.

EVERGREENS OR CONIFERS.

Cedar. There are five different kinds of white cedar in the United States, of which four are different species of the white cedar, and the fifth is what is known as "canoe" cedar. The wood is not very strong, but is light and soft, possessing considerable stiffness and a fine texture. In color it is grayish brown, the sapwood being, however, of a lighter shade than the heartwood. It seasons quickly, is very durable and does not shrink or check to any great extent. Its principal use in carpentry is for shingles, for which its durability makes it especially valuable, and for posts and ties. The trees are usually scattered among others of different kinds, forming occasionally, however, quite considerable forests. They are found all through the northern part of the country and on the Pacific coast in California, Oregon and Washington. Some of the trees are of medium size while others are very large, especially the canoe cedar in the Northwest.

In addition to the white cedars, there are the red cedars, which are similar to the others, but have a somewhat finer texture. There are two varieties, the red cedar and redwood, the former found principally in the southern states and the latter only in California. Red cedar is used but little in building construction except for cabinet work and veneers, but redwood has been used extensively in the West for outside finish, shingles and clapboards. Its resistance to fire is remarkable, which makes it valuable for the exterior of dwellings, but it is too soft for interior finish.

Cypress. This wood is found in the southern states only, where it grows in the swamp land along the banks of the rivers. Although there are a great many varieties, they are similar in their general characteristics and differ only in quality. "Gulf cypress," growing near the Gulf of Mexico, is the best. The timber is light, straight-grained and soft, and is used for shingles and siding, water tables, sills and gutters. It does not warp and shows great resistance to dampness.

Hemlock. There are two varieties of hemlock, one found in the northern states, from Maine to Minnesota, and also along the Alleghanies, southward to Georgia and Alabama; and the other found in the West, from Washington to California, and eastward to Montana. The eastern tree is smaller than the western, and its wood is lighter and softer and generally inferior. The timber is of a light reddish-gray color, fairly durable, but shrinks and checks badly, and is rough, brittle, and usually cross-grained. It is sometimes used in the East for cheap framing, but it is so liable to imperfections such as windshakes and starshakes that it is not suitable for this purpose. It is often used for rough boarding or sheathing.

Spruce. There are three kinds of spruce — white, black, and red, of which the white spruce is the variety commonly found on the market. The wood is light and soft, but fairly strong, and is of a whitish color. It is much used in the northeastern states for light framing, but can be obtained only in small sizes. It is considered by many to be the best framing timber, excepting the pines.

The white spruce is found scattered throughout all of the northern states, along the streams and lakes, the largest varieties being in Montana.

The black spruce is found in Canada and in some of the northern states. It is distinguished from the other varieties only by its leaves and bark.

The red spruce is sometimes known as Newfoundland red pine and is found in the northeastern part of North America. Its wood is similar to the black spruce.

Pines. There are two distinct classes of pines used in building work, the soft and the hard pines, both of which are found in great abundance scattered over the whole of the United States. The great variety of uses to which pine timber may be applied in building construction and the ease with which it can be cut and shipped to market, make it the most popular wood in use at the present time. The softer varieties are used for outside finishing of all sorts, and the harder kinds for heavy framing and for flooring. The tree itself is very tall, with a straight trunk and few branches, so that timbers can be obtained in large sizes and great lengths. There are many different kinds of pines, which are recognized in various parts of the country under various names, but there are five general classes into which the species is commonly divided, though the same timber may be called by different names in two different localities, as will be seen.

1. The term "hard pine" is used to designate any pine which is not white pine, and is a very general classification, though it is often met with in specifications and in works on Carpentry.

2. "White pine," "soft pine" and "pumpkin pine" are terms which are used in the eastern states for the timber from the white pine tree, while on the Pacific coast the same terms refer to the wood of the sugar pine.

3. The name "yellow pine" when used in the northeastern part of the country applies almost always to the pitch pine or to one of the southern pines, but in the West it refers to the bull pine.

4. "Georgia pine" or "longleaf yellow pine" is a term used to distinguish the southern hard pine which grows in the coast region from North Carolina to Texas, and which furnishes the strongest pine lumber on the market.

5. "Pitch pine" may refer to any of the southern pines, or to pitch pine proper, which is found along the coast from New York to Georgia and among the mountains of Kentucky.

Of the soft pines there are two kinds, the white pine and the sugar pine, the latter being a western tree found in Oregon and California, while the former is found in all the northern states from Maine to Minnesota. There is also a smaller species of white pine found along the Rocky Mountain slopes from Montana to New Mexico.

There are ten different varieties of hard pine, of which, however, only five are of practical importance in the building industry. These are the "longleaf southern pine," the "shortleaf southern pine," the "yellow pine," the "loblolly pine" and the "Norway pine."

The longleaf pine, also known as the "Georgia pine," the "yellow pine" and the "long straw pine," is a large tree, which forms extensive forests in the coast region from North Carolina to Texas. It yields very hard, strong timber which can be obtained in long, straight pieces of very large size.

The loblolly pine is also a large tree, but has more sapwood than the longleaf pine, and is coarser, lighter and softer. It is the common lumber pine from Virginia to South Carolina, and is also found in Texas and Arkansas. It is known as well by the name of "slash pine," "old field pine," "rosemary pine," "sap pine," and "short straw pine," and in the West as the Texas pine.

The shortleaf pine is much like the loblolly pine and is the chief lumber tree of Missouri and Arkansas. It is also found in North Carolina and Texas.

The Norway pine is a northern tree found in Canada and the northern states. It never forms forests, but is scattered among other trees, and sometimes forms small groves. The wood is fine-grained and of a white color, but is largely sapwood and is not durable.

BROAD-LEAVED TREES.

Ash is a wood that is frequently employed for interior finishing in public buildings, such as schoolhouses, and in the cheaper classes of dwelling houses. It is one of the cheapest of the hard woods; it is strong, straight-grained and tough, but is coarse in texture. It shrinks moderately, seasons with little injury, and will take a good polish. The trees do not grow together in forests, but are scattered. They grow rapidly, and attain only medium height. Of the six different species found in the United States, only two, the "white ash" and the "black ash," are used extensively in building work. The first is more common in the basin of the Ohio River, but is also found in the North from Maine to Minnesota, and in the South, in Texas. The black ash is found from Maine to Minnesota, and southward to Virginia and Arkansas. There is very little difference between the two species. The black ash is also known as the "hoop ash" and the "ground ash."

Beech. Another wood used to some extent for inside finish is the beech. It is heavy, hard and strong, but of coarse texture like the ash. In color it is light brown, or white. It shrinks and checks during the process of drying and is not durable when placed in contact with the ground. It works easily, stands well, and takes a good polish.

Birch is a very handsome wood of a brown color and with a satiny luster. It takes a good polish, works easily, and does not warp after it is in place, but it is not durable if exposed. It is used quite extensively for inside finish, and to imitate cherry and mahogany, as it has a grain which is very similar to the grain of these woods. The trees are of medium size and form large forests. They are found throughout the eastern part of the United States.

Butternut is also used as a finishing wood, and is cheaper than many of the other harder woods. It is light, but not strong, and is fairly soft. In color it is light brown. The trees, of medium size, are found in the eastern states from Maine to Georgia.

Cherry is a wood which is frequently used as a finishing wood for the interior of dwellings and of cars and steamers; but owing to the fact that it can be obtained only in narrow boards, it is most suitable for moulded work, and work which is much cut up. The wood is heavy, hard, strong and of fine texture. The heartwood is of a reddish brown color, while the sapwood is yellowish white. It is very handsome and takes a good polish, works easily and stands well. It shrinks considerably in drying. The timber is cut from the wild black cherry tree, which is of medium size and found scattered among the other broad-leaved trees along the western slope of the Alleghanies and as far west as Texas.

Chestnut timber is used in cabinet work, for interior finishing, and sometimes for heavy construction. It is light, fairly soft, but not strong. It has a rather coarse texture, works easily and stands well, but shrinks and checks in drying. The timber is very durable. The tree grows in the region of the Alleghanies, from Maine to Michigan, and southward to Alabama.

Elm. There are five species of elm trees in the United States, scattered throughout the eastern and central states. The trees are usually large and of rapid growth, and do not form forests. The timber is hard and tough, frequently cross-grained, hard to work, and shrinks and checks in drying. The wood has not been used very extensively in building, but has a beautiful figured grain, can take a high polish, and is well adapted to staining. The texture is coarse to fine, and the color is brown with shades of gray and red.

Gum. The wood of the gum tree is used extensively for cabinet work, furniture, and interior finish. It is of fine texture and handsome appearance, heavy, quite soft, yet strong, and reddish brown in color. It warps and checks badly, is not durable if exposed, and is hard to work. The species of gum tree used in carpentry is the sweet gum, which is of medium size, with straight trunk; it does not form forests, though it is quite abundant east of the Mississippi River.

Maple. Almost all of the maple used in building work comes from the sugar maple tree, which is most abundant in the region of the Great Lakes, but which is also found from Maine to Minnesota, and southward to Florida. The trees are of medium to large size, and form quite considerable forests. The wood is heavy and strong, of fine texture, and often has a fine wavy grain which gives the effect known as "curly." It is of a creamy white color, shrinks moderately, works easily and takes a good polish. It is often used for flooring, and sometimes for other inside finish.

Oak. There are about twenty different kinds of oak to be found in various parts of the United States, but there are three distinctly different species, which are sold separately. These are the "white oak," the "red oak" and the "live oak." The red oak is usually more porous, less durable and of coarser texture than the white oak or the live oak. The trees are of medium size and form a large proportion of all the broad-leaved forests. Live oak was once extensively used, but has become scarce and is now expensive. Both the red oak and the white oak are used for inside finishing, but they are liable to shrink and crack and must therefore be thoroughly seasoned. They are of slightly different color, the white oak having a straw color while the red oak has a reddish tinge, so that they cannot be used together where the work is to be finished by polishing. Oak is always better if quarter-sawed, when it shows what is known as the "silver grain."

Poplar. This wood is also known as "whitewood" and "tulip wood." There are a number of different varieties growing in various parts of the country. The tree is large, and is most common in the Ohio Basin, but does not form forests. The wood is light, soft, free from knots, and of fine texture. In color it is white, or yellowish-white, and frequently it has a satiny luster. It can be so finished as to retain its natural appearance, but it is often stained to imitate some of the more costly woods, such as cherry. It is used extensively for cheap inside finish and fittings, such as shelving, and sometimes for doors, but it warps badly if it is not thoroughly seasoned.

Sycamore is frequently used for finishing, and is a very handsome wood. It is heavy, hard, strong, of coarse texture, and is usually cross-grained. It is hard to work, and shrinks, warps, and checks considerably. The tree is of large size and rapid growth, found in all parts of the eastern United States, but is most common along the Ohio and Mississippi Rivers.

Black Walnut is a wood which has been and is still used very extensively for interior finishing and in the manufacture of furniture It is a heavy, hard timber, of coarse texture, and of a dark-brown color. Very handsome pieces having a beautiful figure, may be selected for veneers for furniture and cabinet work. Although the wood shrinks somewhat in drying, it works easily, stands well, and will take a very good polish. The tree is large and of rapid growth. It was formerly very abundant in the Alleghany region, and was found from New England to Texas and from Michigan to Florida, but it is now becoming scarcer and the timber is expensive.

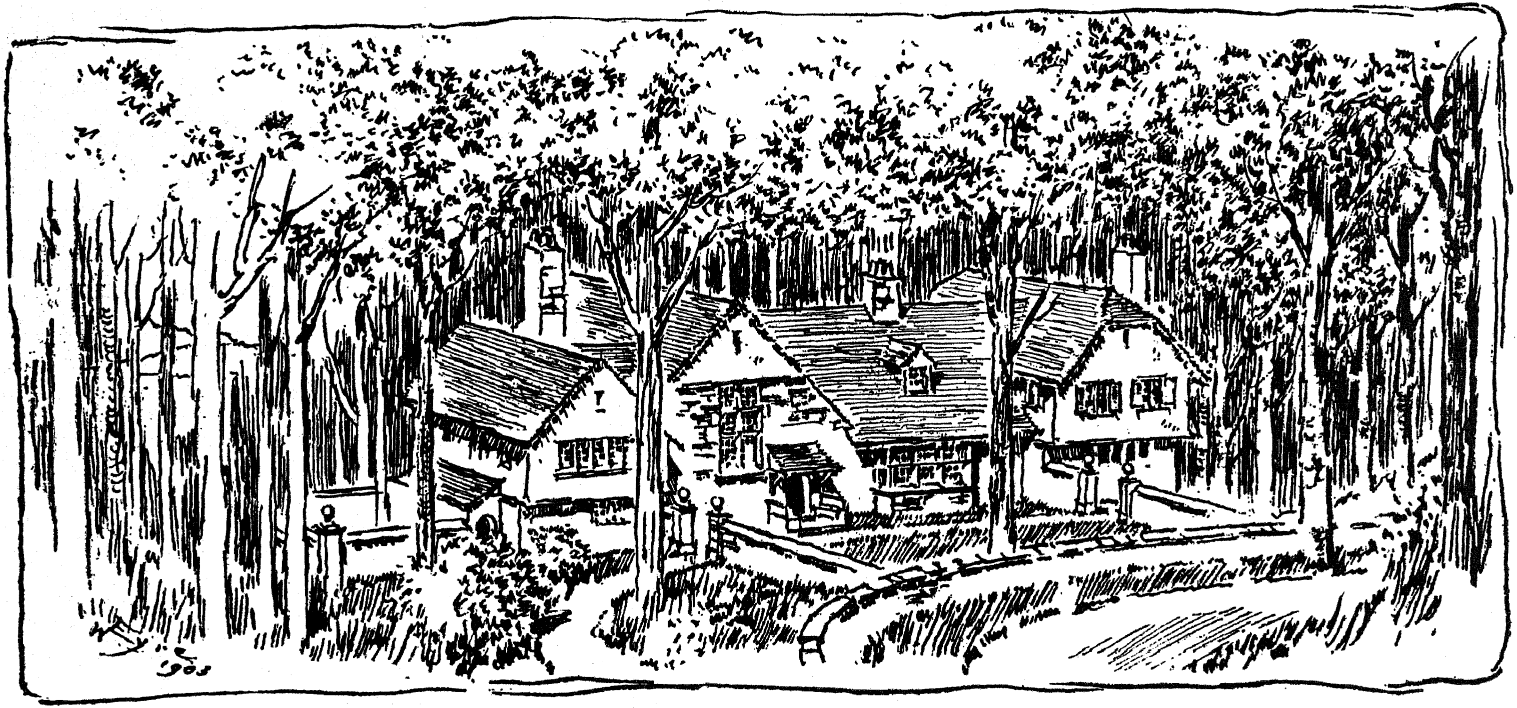
Imported Timber. Besides the woods which grow in the United States, a number of others are brought in from foreign lands for use in the best grade of public buildings and private residences. The most popular of these are the mahogany, rosewood, satinwood, French burl, and Circassian walnut.

Mahogany comes from Cuba and Mexico, and formerly was obtained also from Santo Domingo and Honduras. It is generally imported in the rough log and cut up by the purchasers as it is required. The wood is easy to work, will take an excellent polish, and stays in place very well if it is well seasoned. It varies in color from very light to deep red and becomes darker with age. It is usually employed in the form of veneers on account of its cost.

Satinwood comes from the West Indies, French burl from Persia, and Circassian walnut from near the Black Sea. They are all very expensive and are used only as veneers, and in only the finest work.

GENERAL CHARACTERISTICS OF TIMBER.

In speaking of wood we are accustomed to use certain words to express our idea of its mechanical properties, or of its probable



HOUSE AT TUXEDO PARK, N. Y.

Wilson Eyre, Architect, Philadelphia and New York
Plans and Rear Elevation of this House are Shown on Page 42.

behavior under certain conditions. Thus we say that a wood is hard, or tough, or brittle, or flexible, and frequently we use these terms without having a clear understanding of just what they mean. A very brief discussion of some of these properties or characteristics of timber will now be given in order that we may see what peculiarities of structure or of growth cause them.

Hardness. If a block of wood is struck with a hammer when lying on a bench, the hammer-head will make an impression or dent in the wood, which will be deeper or shallower according as the wood is soft or hard. A wood is said to be very hard when it requires a pressure of about 3,000 pounds per square inch to make an impression one-twentieth of an inch deep. A hard wood requires only about 2,500 pounds to produce the same effect. Fairly hard wood will be indented by a pressure of 1,500 pounds, and soft woods require even less. Maple, oak, elm and hickory are very hard; ash, cherry, birch and walnut are hard; the best qualities of pine and spruce are fairly hard; and hemlock, poplar, redwood and butternut are soft.

Toughness. "Toughness" is a word which is often used in relation to timber, and implies both strength and pliability, such as is found in the wood of the elm and hickory. Such timber will withstand the effect of jars and shocks which would cause other woods, like pine, to be shattered.

Flexibility. Timber is said to be flexible when it bends before breaking instead of breaking off short, or, in other words, a flexible wood is the opposite of one which is brittle. The harder woods, taken from the broad-leaved trees, are usually more flexible than the softer woods, taken from the cone-bearing trees. The wood of the main tree trunk is more flexible than that of the limbs and branches, and moist timber is more flexible than dry wood. Hickory is one of the most flexible woods.

Cleavage. Most woods split very easily along the grain, especially when the arrangement of the fibers is simple, as in the conifers. In splitting with an axe, the axe-head acts as a wedge and forces the fibers apart, and usually the split runs along some distance ahead of the axe. Hard woods do not split so easily as soft woods, and seasoned wood not so easily as green wood, while all timber splits most easily along radial lines.

THE STEEL SQUARE.

If it is important that a workman should know his material thoroughly, it is even more essential that he should understand his tools and be able to apply them in the most useful way to any particular piece of work. This is especially true of the tool known as the "Carpenter's Steel Square" which is without doubt the most useful of all the tools to be found in a carpenter's chest, but which is not always thoroughly understood even by experienced workmen. As the square will be referred to frequently in these pages a brief description of it will be given.

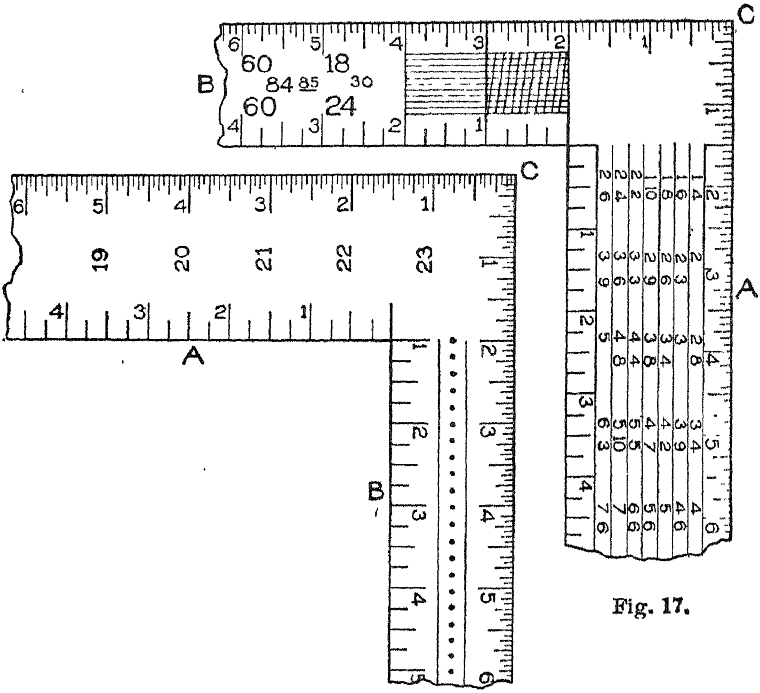


Fig. 17.

Fig. 16. Carpenter's Steel Square.

It is shown in Figs. 16 and 17, each view showing one side of the square. It is essentially a measuring and calculating tool, and all of the various markings and scales found on either side have their own special uses. All squares are not alike, there being several kinds on the market and in daily use among mechanics, but the variations in the markings on the different squares are so slight that if one is explained the others can be readily understood.

There are three parts to the tool which are distinguished by special names, the tongue, the blade and the heel. The longer, wider arm is called the blade; the shorter, narrower arm is called the tongue; and the point in which the tongue and the blade meet, on the outside edge of the square, is called the heel. In the figures, A is the blade, B the tongue, and C the heel. In carefully made tools, the blade is two feet long and two inches wide, while the tongue is from fourteen to eighteen inches long and one and one-half inches wide.

Starting at the heel and reading away from it, the outside edges of the blade and the tongue on both sides of the square, are divided into inches and fractions of an inch, one side of the square showing sixteenths and the other side showing twelfths. Starting at the interior angle opposite the heel, the inside edges are divided in a similar way except that the inches on both sides of the square are divided into eighths only. In some squares one of these scales is shown divided into thirty-seconds of an inch. On one side of the blade the inch marks are numbered in both directions, from the heel outward, and also from the end of the blade inward, toward the heel, so that each inch mark has two numbers, one showing its distance, in inches, from the heel, and the other showing its distance from the end of the blade. These extra numbers are very useful in measuring the depth of mortises and in all similar work. The arrangement is shown in Fig. 16.

On the other side of the blade, which is shown in Fig. 17, in addition to the scales on the two edges, we find a column of figures directly under each of the inch marks on the outer edge. The figures are arranged in eight rows, parallel to the edges of the square. and the rows are marked off by lines running the full length of the blade. These figures enable a man to tell at a glance the number of board-feet in a piece of timber whose dimensions he knows. Under the twelve-inch mark there are figures showing the different lengths which can be measured in this way, so that each row of figures corresponds to a certain length, found under the twelve-inch mark. Under each of the other inch marks there are figures, each of which gives the number of board-feet in a plank one inch thick, whose width in inches is indicated by the number of the inch marks under which the figure is found, and whose length, in feet, is indicated by the number found in the same row with the figure itself under the twelve-inch mark. There are seven or eight different lengths given, and twenty-three different widths for each length, the widths varying from two inches up to twenty-four inches. The figures expressing the board measure are given as feet and inches, the number of feet being separated from the number of inches by a vertical line, with the feet on the left and the inches on the right. For instance, 11 8 is read as eleven feet and eight inches.

On the same side of the square which shows the board measure on the blade, we find on the tongue what is known as the "brace rule," placed in the middle of the tongue between the two scales which are marked off along the edges. The brace rule consists of two similar numbers representing length in feet, placed one above the other, with a third number placed just to the right of them, as $\genfrac{}{}{0pt}{}{24}{24}$ 33.94. The two similar numbers represent the length, in feet, of the side of a perfect square, and the third number represents the length of the diagonal of this square, expressed in feet and decimals of a foot. In other words the number to the right is equal to the square root of the sum of the squares of the other two numbers, or is equal to one of these numbers multiplied by the square root of 2, which is 1.414, in accordance with the principle that the length of the diagonal of a square is equal to the length of the side multiplied by the square root of two. There are a number of different sets of figures like this on the tongue of the square; they are very useful in finding the length of braces which make an angle of forty-five degrees with the post into which they frame, or which have a total rise equal to their total run.

On the same side of the tongue which shows the brace rule, placed near the heel of the square, is found another scale which may be called the "Scale of Hundredths." It consists of a number of lines drawn along the tongue parallel to the edges, which are just one-tenth of an inch apart.

They are drawn diagonally, so that the end of one line is directly under the starting point of the next line. By means of this scale any number of hundredths of an inch can be readily measured off. The scale may be seen in Fig. 17.

The opposite side of the square shows two lines, drawn near together in the center of the tongue. Parallel to the edges and between these lines a single line of dots is placed. They are a little more than one-fifth of an inch apart and numbered by tens. The dots constitute what is called the "octagon scale," and are used in the process of cutting a stick of octagonal section out of a stick of square section Suppose for example we take a stick ten inches square and wish to cut from it a stick of octagonal section. We will first draw a line lengthwise in the center of each of the four faces of the square stick. Then applying the square, we measure off on both sides of this center line, in each face, perpendicular to the edges of the piece, as many of the spaces shown by the line of dots as there are inches in the side of the square stick. Thus in this case, we measure off ten spaces on each side of each center line, and then draw through the points thus located two lines in each face, parallel to the center line and equidistant from it. These eight lines represent the eight edges of the octagonal stick, and by cutting away the four corners, the desired shape is obtained.

This completes the description of the markings upon the square, and although there are undoubtedly some squares in use which may not be exactly like the model described, they all have nearly the same markings, arranged in the same way or with but slight variations.

Some of the numerous applications of the square in the solution of practical problems in Carpentry are explained in connection with the work on "framing," and others will suggest themselves to the thoughtful student. The uses to which the instrument may be put are so many and so various that it would require a large book to explain them all, but those who use the tool constantly will readily discover them and perhaps many new ones besides.

LAYING OUT.

Having now considered the material and the most important of the tools with which the carpenter performs his work, we shall pass to a consideration of the work itself, and see how a building of wooden construction is put together.

In undertaking the construction of any building, the first thing to do is to make a very thoughtful examination of the piece of ground upon which the structure is to be placed. This is very important, since the character of the soil upon which a dwelling is located will very largely determine its sanitary condition, and will influence to a great extent the health of the occupants. Very often a difference of a few yards in the position of a building will be enough to cause the difference between a perfectly dry cellar and one which is constantly flooded with water. Water is, indeed, the one thing above all others which must be guarded against, since it is almost impossible to keep it out of a cellar which is sunk in damp ground.

At a certain distance below the surface of the earth there is always to be found what is known as "ground water." This stands always nearly at a level, so that it is not met with so near the surface of a slight knoll or other elevation as in the case of a depression. If possible, the house should be so located that the bottom of the cellar need not come below the ground-water level, and consequently it should be placed on comparatively high land. Below the surface of a hill, however, there may be a stratum of rock which will hold the rain water and prevent it from sinking at once to the ground-water level. Such a ledge of rock causes the water to collect, and then flow off in small subterranean streams, which will almost surely penetrate the walls of a cellar if it happens to be in their path.

A good way to discover the depth of the ground-water level, or the existence of rock ledges beneath the surface of the ground, is to dig a number of small, deep holes at various points of the site. These should be carried below the proposed level of the cellar bottom. A suitable location for the building may thus be chosen.

When the approximate position of the structure has been decided upon, the next step is to "stake it out." That is, the position of the corners of the building must be located and marked in some way on the ground, so that when the excavation is begun the workmen may know what are the exact boundaries of the cellar. This "staking out" should always be carefully attended to, no matter how small the building may be. In works of importance it is always best to have the work done by an engineer, but on small work it is customary for the contractor or the architect to attend to it. It is well to have at hand some instrument with which angles can be accurately measured, such as a transit; but the work can be done very satisfactorily with a tape measure and a "mason's square." This simple instrument is composed of three sticks of timber nailed together as shown in Fig.

18, to form a right-angled triangle. It is important that the tape used should be accurate, a steel tape being always preferable, and that the square should give an exact right angle. A mistake in the staking out may cause endless trouble when the erection of the building itself is begun, and it is then too late to remedy it.

There are several different lines which must be located at some time during the construction, and they may as well be settled at the start. These are: the line of excavation, which is outside of all; the face of the basement wall, inside of the excavation line; and, in the case of a masonry building, the ashlar line, which indicates the outside of the brick, or stone walls. In the case of a wooden structure only the two outside lines need be located, and often only the line of the excavation is determined at the outset.

The first thing to do is to lay out upon the ground the main rectangle of the building, after which the secondary rectangles which indicate the position of ells, bay windows, etc., may be located Starting at any point on the lot where it is desired to place one corner of the building, a stake should be driven into the ground and a line laid out either parallel or perpendicular to the street upon which the structure is to face. At the end of this line, which forms one side of our rectangle, and the length of which is determined by the dimensions of the building, another stake should be driven, and these two stakes will determine the direction and the length of the line. The exact location of the ends of the line may be indicated by a nail driven into the top of each stake.

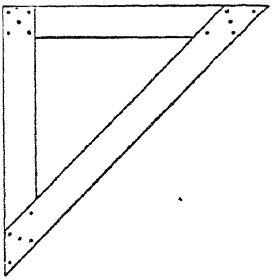


Fig. 18. Mason's Square.

After one line has been thus laid out, others may be laid out perpendicular to it at its ends, with the aid of the mason's square and the tape measure. The accuracy of the right angle may be checked by the use of the "three-four-five" rule. This rule is based upon the fact that a triangle, whose three sides are respectively three, four, and five feet long, is an exact right-angled triangle, the right angle being always the angle between the three-foot and the four-foot sides. This fact may be proven by applying the well-known theorem which states that the length of the hypothenuse of a right-angled triangle is equal to the square root of the sum of the squares of the other two sides The rule may be used as follows :

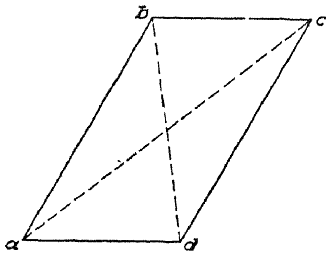


Fig. 19.

Lay off on one of the side lines already laid out on the ground, any multiple of three feet, as nine feet, or twelve feet. On the other line, presumably at right angles to the first one, lay off the same multiple of four feet, as twelve feet, or sixteen feet. Now a straight line, measured between the points so obtained, should have a length equal to the same multiple of five feet, as fifteen feet or twenty feet. If this is not found to be the case, the angle laid out is not an exact right angle, and instead of a rectangle we have a parallelogram as shown in Fig. 19. This will not do at all, and the inaccuracy must be corrected. It is possible to lay out the right angle in the first place by this same method, using two flexible cords, respectively four feet and five feet long. The end of the four-foot cord should be fastened at the end of the side line of the building, and the end of the five-foot cord should be fastened on this same side line, three feet away from the corner. When the loose ends of both cords are held together, and the cords are both drawn taut, the point where the ends meet will be a point on the side line of the building perpendicular to the first side line. It is evident that this point must be just four feet from the corner, and that the distance between it and the point on the other side line, three feet from the corner, must be five feet.

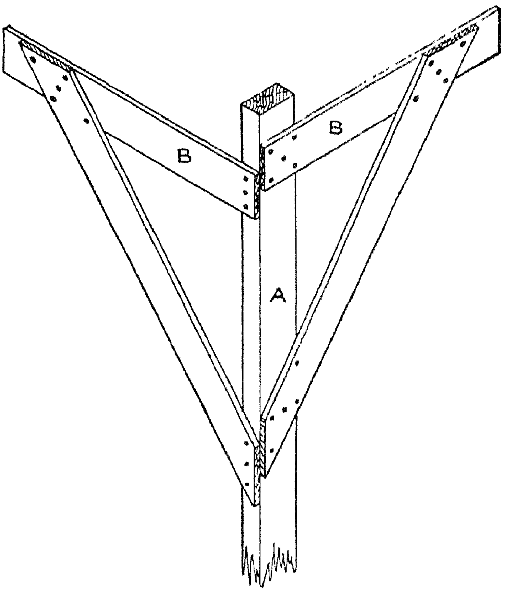


Fig. 20 Position of Corner.

After all the corners of the building have been located, their position should be indicated by the use of "batter boards." One of these is shown in Fig. 20. It will be seen that it consists of a post A, which is set up at the corner, together with two horizontal pieces B, B, which extend outward for a short distance along the sides of the rectangle that has been laid out. The horizontal pieces may be braced securely as shown, and the whole will be a permanent indication of the position of the corner. Notches may be cut in the top of the horizontal pieces to indicate the position of the various lines, and cords may then be stretched between the notches from batter board to batter board. These cords will give the exact location of the lines.

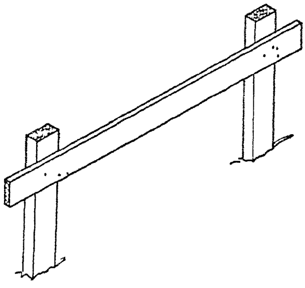


Fig. 21. Batter Boards.

Another way to indicate the position of the lines is by driving small nails into the tops of the batter boards instead of cutting notches in them; but nails may be withdrawn, while the notches, when they are once cut, cannot easily be obliterated.

Batter boards should always be set up very securely, so that they will not be displaced during the building operations. If there is danger that the form of batter board shown in Fig. 20 may be displaced, because of the large size of the structure and the length of time during which they must be used, the form shown in Fig. 21 may be substituted. Two of these, at right angles to each other, must be placed at each corner.

LIGHT FRAMING.

After the building has been laid out, and the batter boards are in place, the next work which a carpenter is called upon to do is the framing. This consists in preparing a skeleton, as we may say, upon which a more or less ornamental covering is to be placed. Just as the skeleton is the most essential part of the human body, so is the frame the most essential part of a wooden building; and upon the strength of this frame depends the strength and durability of the structure. When the carpenter comes to the work, he finds everything prepared for him; the cellar has been dug and the foundation walls and the underpinning have been built. It is his business to raise the framework on top of them. First is the wall, then the floors and the roof. Therefore the subject may be subdivided, and considered under these three main headings. In connection with the walls we may consider the partitions as well as the outside walls, and in connection with the floors we may consider the stairs, while the roof may be taken as comprising the main roof and also subordinate roofs over piazzas, balconies and ells. This covers all the framing that will be found in a wooden building, except special framing, which will be treated later. Whatever framing there is in a brick or stone building is similar to that in a wooden building, with the slight differences which may be noted as we come to them.

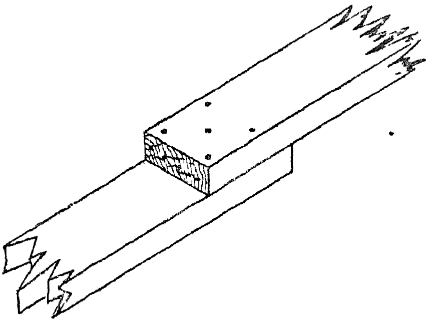


Fig. 22. Splice.

JOINTS AND SPLICES.

Joints. Before beginning a description of the framing of the wall, it will be well to consider the methods employed in joining pieces of timber together. The number of different kinds of connections is really very small, and the principles upon which they are based may be mastered very quickly.

All connections between pieces of timber may be classified as joints or as splices. By a "splice" we mean a connection between two pieces which extend in the same direction, as shown in Fig. 22, and each one of which is merely a continuation of the other. The only reason for the existence of such a connection is the fact that sticks of timber can be obtained only in limited lengths, and must therefore very often be pieced out. By a "joint" we mean any connection between two pieces which come together at an angle, as

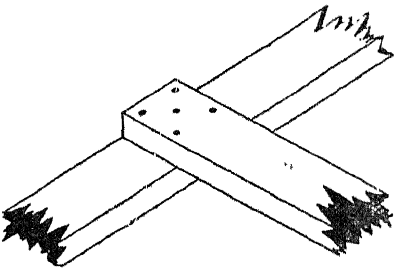


Fig. 23. Joint.

shown in Fig 23, and which are therefore not continuous. Such a connection may be required in a great many places, and especially at the corners of a building.

Joints. The principal kinds of joints to be met with in carpentry are the "butt joint," the "mortise-and-tenon joint," the "gained joint," the "halved joint," the "tenon-and-tusk joint," and the "double tenon joint."

The Butt Joint. This is the most simple of all the joints, and is made by merely placing the two pieces together and nailing them firmly to each other, after both have been trimmed square and true. Such a joint is shown in Fig. 24. The two pieces are perpendicular to each other and neither piece is cut. The nails are driven diagonally through both pieces, an operation which is known as "toe-nailing," and are driven home, if necessary, with a nail set. This is called a "square" butt joint. Fig. 25 shows two pieces which are not perpendicular to each other. They are trimmed to fit closely together, and are then nailed in place. Such a joint is called an "oblique" butt joint. The butt joint does not make a strong connection between the pieces, and should not be used if much strength is required. It depends entirely upon the nails for its strength, and these are very likely to pull out.

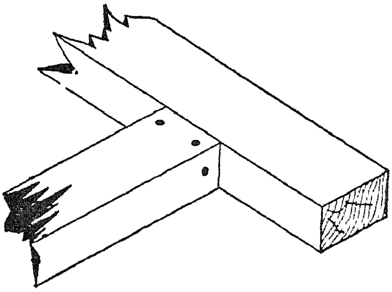


Fig. 24. Butt Joint.

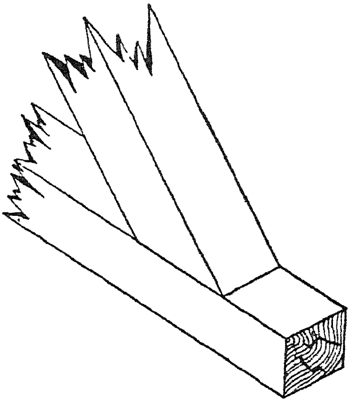


Fig. 25. Oblique Butt Joint.

This form of joint is sometimes modified by cutting away a part of one of the pieces, so that the other may set down into it as shown in Fig. 26, the square joint at A, and the oblique joint at B. This gives much additional strength to the joint, especially in the case shown at B, where there may be a tendency for one piece to slide along the other.

The Mortise-and-Tenon Joint. From the modified butt joint it is only a step to the "mortise-and-tenon" joint, which is formed by cutting a hole called a "mortise" in one of the pieces of timber, to receive a projection called a "tenon" which is cut on the end of the other piece. This is shown in Fig. 27. The mortise is at *a* and the tenon at *b*. It will be noticed that there is a hole bored

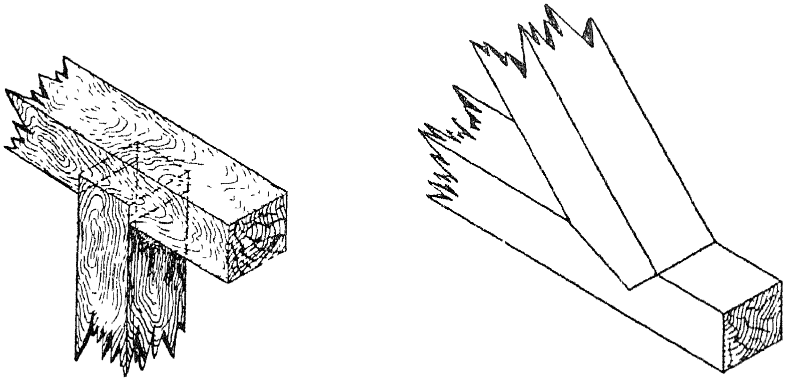


Fig. 26 A. Modified Butt Joints. Fig. 26 B.

through the tenon at *c*, and another hole in the mortised piece at *d*. These holes are so placed that when the pieces are joined together, a wooden pin may be driven through both holes, thus preventing the tenon from being withdrawn from the mortise. This pin should *always* be inserted in a mortise-and-tenon joint. Ordinarily it is of hard wood even when the pieces to be joined are themselves of soft wood, and it may be of any desired size. Round pins from three-quarters to seven-eighths of an inch in diameter are ordinarily employed, although it may sometimes be found better to use a square pin.

The Bridge Joint. The form of mortise-and-tenon joint described above may be used wherever the pieces are perpendicular to each other. When, however, the pieces are inclined to each other, a modification of the above joint known as the "bridge" or "straddle" joint is employed. This joint is shown in Figs. 28 and 29. It is similar to the square mortise-and-tenon joint, having a similar mortise and tenon, but these are cut in a slightly different way. In Fig. 28 the tenon *a* is cut in the end of the inclined piece and fits into the mortise *b* cut in the other piece.

In Fig. 29 the mortise *a* is cut in the end of the inclined piece and the tenon *b* is cut in the other piece.

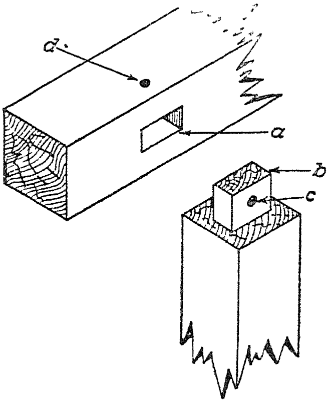


Fig. 27. Mortise-and-Tenon Joint.

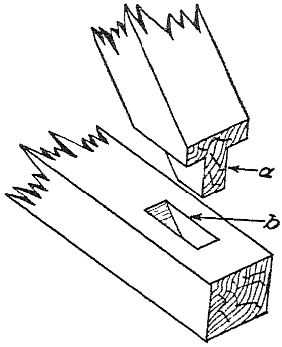


Fig. 28. Bridge Joint.

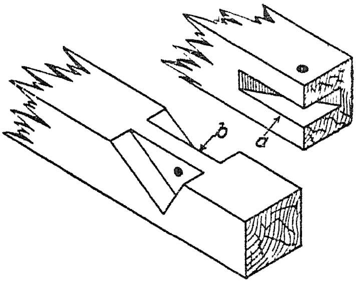


Fig. 29. Bridge Joint.

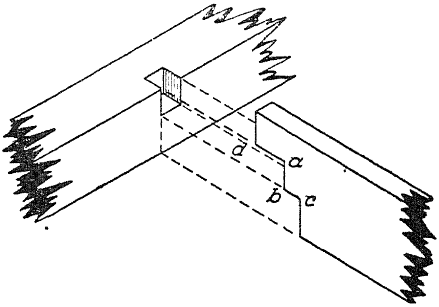
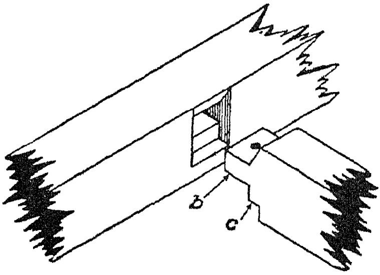


Fig. 30. Gained Joint.

The Gained Joint. The joints which have so far been described are applicable only where the members are subjected to direct compression, as in the case of posts or braces, or in certain cases where direct tension is the only force acting on the pieces. When bending and shearing are to be expected, as in the case of floor beams connecting to sills or girders, a slightly different sort of joint must be employed.

One of the most common joints for such places is a modification of the mortise-and-tenon joint which is known as the "gained joint." An example of this form of connection is shown in Fig. 30, and it may be seen that the end of one piece is tenoned in a peculiar way. The tenon proper is the part *a-b-c* and this tenon sets into a corresponding mortise cut in the other piece as shown. It is evident that the tenon cannot be held in place by a pin, but it may be secured by nailing.

The reason for this peculiar form of tenon may be explained as follows: A floor beam, or any other timber which is loaded transversely, has a tendency to fall to the ground, and must be supported at its ends either by resting directly on a wall or sill, or by being mortised into the latter member. Moreover, in order that the end of the piece resting on the support may not be crushed or broken, a certain amount of bearing surface must be available. This same bearing surface must be provided in every case no matter whether the timber rests directly on the top of the sill or is mortised into it. Of course the simplest connection is obtained by resting the transverse piece directly on top of the sill without cutting either piece; but such a joint is not stiff and strong, and it is often necessary to bring the timbers flush with each other at the top or at the bottom. For this reason a mortised joint is used; and in order to obtain the required amount of bearing surface without cutting the pieces too much, the form of tenon shown is employed. The available bearing area here is furnished by the surfaces *d-a* and *b-c* and it may easily be seen that this area is the same as would be available if the piece rested directly on top of the sill.



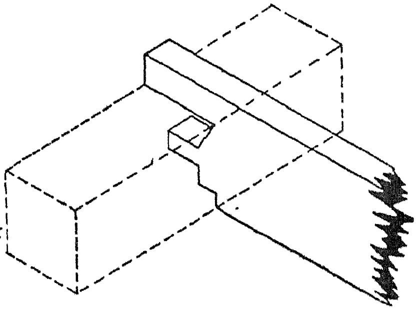
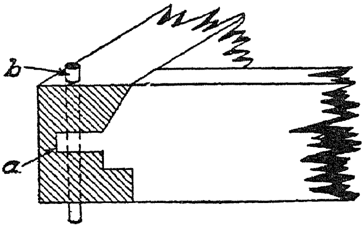


Fig. 31. Tenon-and-Tusk Joints. Fig. 32.

The operation of cutting such a tenon and mortise is known as "gaining," and one piece is said to be "gained" into the other.

The Tenon-and-Tusk Joint. A joint in very common use in such situations as have just been mentioned is a development of the gained joint which is called the "tenon-and-tusk" or the "tusk-tenon" joint. This joint is shown in Fig. 31. The characteristic feature is to be found in the peculiar shape of the tenon which is cut in the end of one of the pieces to be joined, as shown in the figure. It may be seen that there is a small square tenon *b* cut in the extreme end of the piece, and that in addition to this there are other cuts *c* which constitute the "tusk." The bearing area is furnished partly by the under side of the tenon and partly by the under side of the tusk.



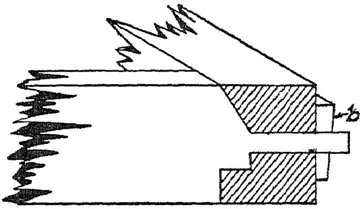


Fig. 33. Methods of Securing Tenons. Fig. 34.

This joint makes a very good connection, and the cutting of the mortise does not weaken the piece of timber so much as does the mortise for a gained joint. It is especially applicable when it is desired to have the pieces flush on top, though it may also be used in other positions. When the top of the tenoned piece must project above the top of the mortised piece, the tenon may be cut as shown in Fig. 32.

There are several ways of securing the tenon in place. The simplest is that shown in Fig. 33, where the pin *b* is passed through the tenon and the mortised piece so as to hold the tenon securely in place. Another scheme is to cut the square tenon a little longer, as shown in Fig. 34, so as to pass clear through the mortised piece, and to fasten it with a peg *b* on the other side. The peg may be cut slightly tapering, as shown, so that when it is driven in place it will draw the pieces together. Still another plan is shown in Fig. 35. Here a small square hole *a* is cut in the header some

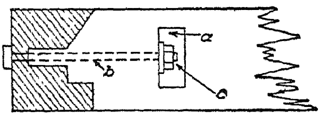


Fig. 35.
Method of Securing Tenon.

distance back from the tenon and a nut *c* is placed in it, while a bolt *b* is passed through a hole bored lengthwise in the header to receive it. The bolt passes through the nut, which may be screwed up tight, thus drawing the pieces closely together and making the joint tight. In screwing this up, it is the bolt which must be turned, while the nut is held stationary by the side of the square hole in which it is inserted and which is just large enough to receive it.

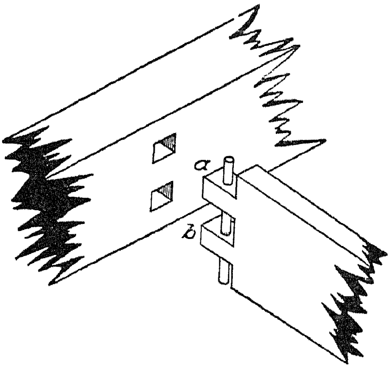


Fig. 36. Double Tenon Joint.

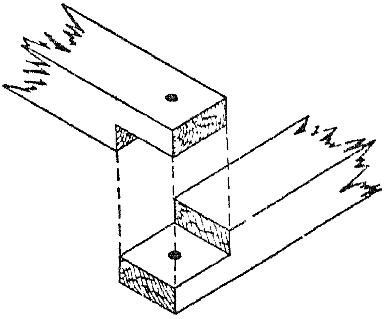


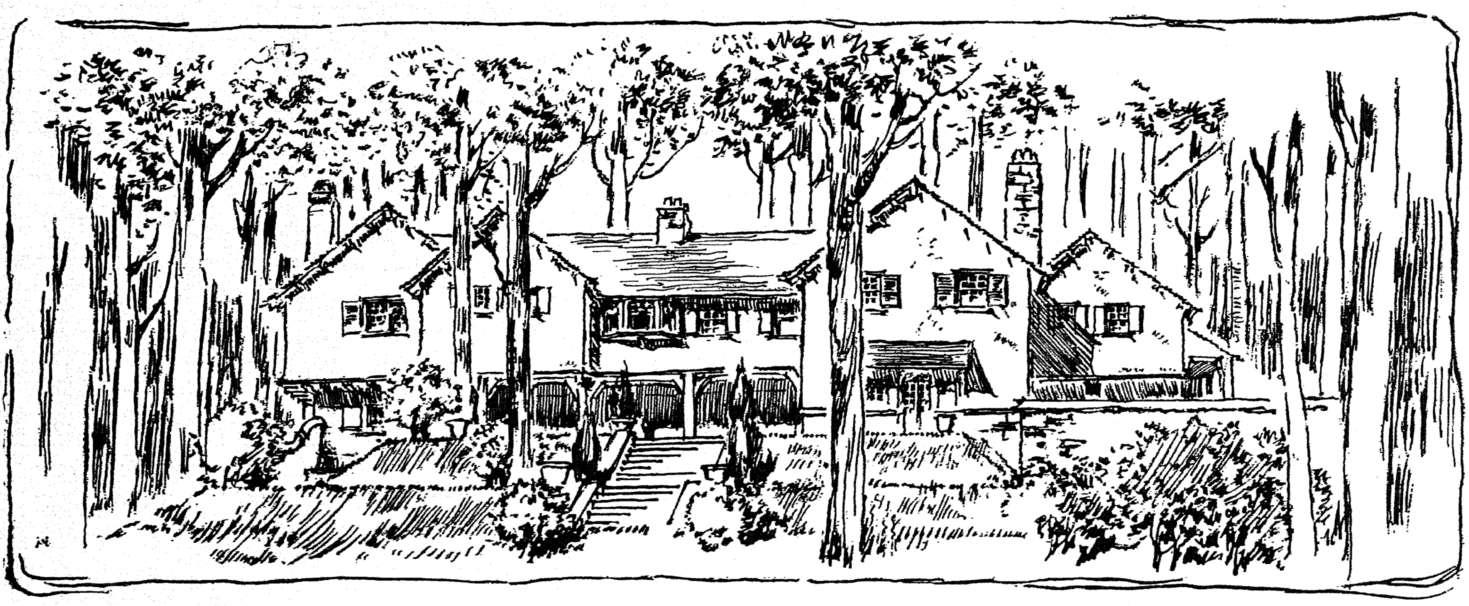
Fig. 37. Halved Joint.

The Double Tenon Joint. Fig. 36 shows a form of tenon joint called the "double tenon" joint, which is not very extensively used at the present time but which has some advantages. As may be readily seen, there are two small tenons *a* and *b* through which a pin may be passed if desired.

The Halved Joint. A form of joint which may be used to connect two pieces that meet at a corner of a building, is shown in Fig. 37.

This is known as the "halved" joint from the fact that both pieces are cut half way through and then placed together. The pieces are held in place by nails or spikes.

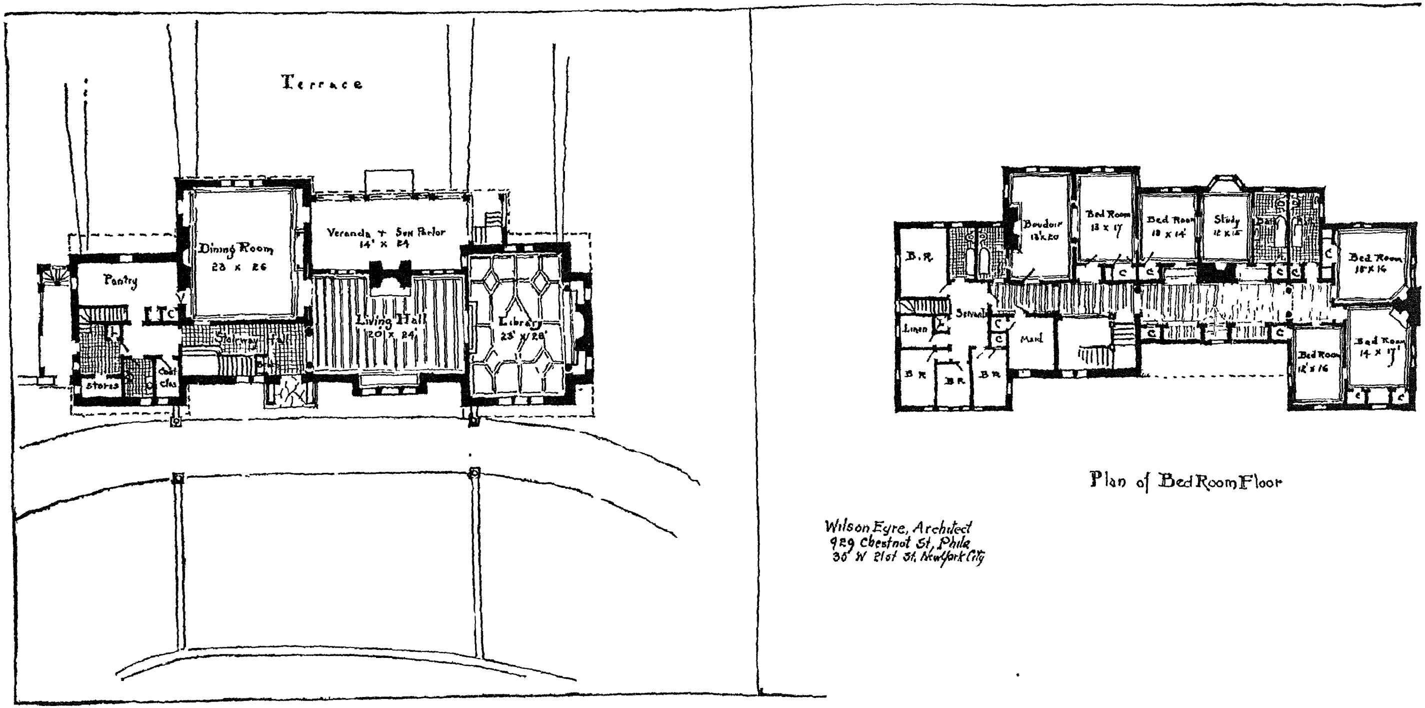
If one piece meets the other near the center instead of at the end of the piece, and if there is danger that the two pieces may pull away from each other, a form of joint called the "dovetail" halved joint is used. This is shown in Fig. 38. Both the tenon and the mortise are cut in the shape of a fan, or dovetail, which prevents them from being pulled apart. This joint may also be



GARDEN FRONT OF HOUSE AT TUXEDO, NEW YORK.

Wilson Eyre, Architect, Philadelphia and New York

Exterior Walls of Rough-Cast on Wood Lath; Roofs of Shingles.
For View of Main Front of House, See Page 26.



Plan of Bed Room Floor

Wilson Eyre, Architect
929 Chestnut St, Phila
30 W 21st St. New York City

HOUSE AT TUXEDO PARK, NEW YORK, FOR MR. HARLSTON DEACON.

Wilson Eyre, Architect, Philadelphia and New York

Built in 1903-04. Cost, about $30,000. For View of Front of House, See Page 26.

cut as shown in Fig. 39, with the flare on only one side of the tenon, the other side being straight.

Splices. As already explained, a splice is merely a joint between two pieces of timber which extend in the same direction, and is sometimes necessary because one long piece cannot be conveniently or cheaply obtained. The only object in view, then, is to fasten the two timbers together, in such a way that the finished piece will be in all respects equivalent to a single unbroken piece, and will satisfy all the requirements of the unbroken piece. This is really the only measure of the efficiency of a splice.

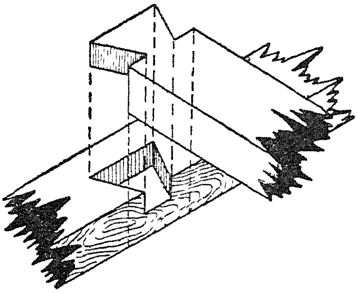


Fig. 38. Dovetail Halved Joint.

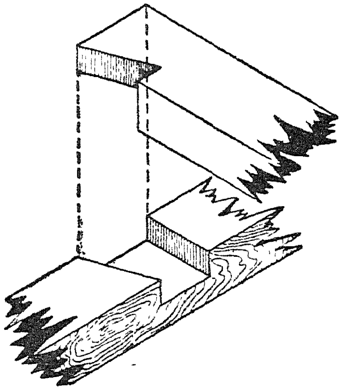


Fig. 39. Dovetail Joint.

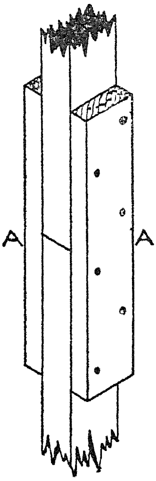


Fig. 40.
Fished Splice.

There are three kinds of forces to which a piece may be subjected, namely: compression, tension, and bending. A splice which would be very effective in a timber acted upon by one of these forces might be absolutely worthless in a piece which must resist one of the other forces. We have, therefore, three classes of splices, each designed to resist one of these three forces.

Splices for Compression. The simplest splices are those to resist compression alone, and of these the most simple is that shown in Fig. 40. This piece is said to be "fished;" the two parts are merely sawed off square and the ends placed together. A couple of short pieces A A, called "fish plates" are nailed on opposite sides to keep the parts in line. In the splice shown in Fig. 40, these are of wood, and ordinary nails are used to fasten them in place, but in more important work thin iron plates are used, the thickness being varied to suit the conditions. They are held in place by means of bolts with washers and nuts.

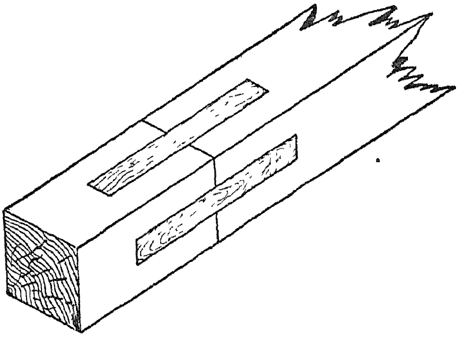


Fig. 41. Splice Using Dowels.

If for any reason, it is desired not to use plates of this kind, four small pieces called dowels may be used, as indicated in Fig. 41. These dowels may be set into the sides of the timbers to be spliced, so that they do not project at all beyond the faces of these pieces and a very neat job may thus be obtained.

It is but a step to pass from this simple splice to the "halved" splice shown in Fig. 42. It will be noticed that it is much like the halved joint described above, the only difference being that the pieces are continuous, instead of perpendicular to each other. The nature of the splice will be easily understood from the figure without further explanation. A modification of this which is somewhat more effective, is shown in Fig. 43. The cuts are here made on a bevel in such a way that the parts fit accurately when placed together, and the splice is called a "beveled" splice.

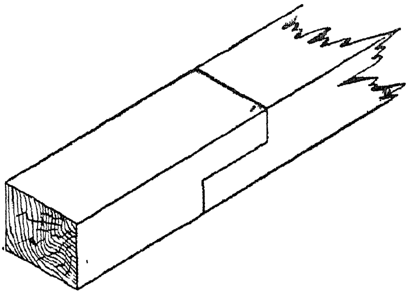


Fig. 42. Halved Splice.

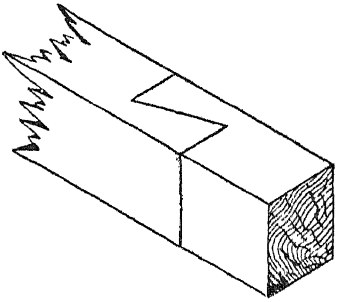


Fig. 43. Beveled Splice.

The halved splice is perhaps the best that can be used to resist direct compression, and when it is combined with fish plates and bolts as shown in Fig. 44 it may be used in cases where some tension is to be expected. It will be noticed that in Fig. 44 the ends of the timbers are cut with a small additional tongue *a* but this does not materially strengthen the splice and it adds considerably to the labor of forming it. In general it may be said that the simplest splice is the most effective.

Whenever the pieces are cut to fit into one another, as they do in the halved and beveled splices, the splice is known as a "scarf" splice, and the operation of cutting and joining the parts is called "scarfing." Scarf splices are used, as we have already seen, both alone and in combination with fish plates. The fished splice is always the stronger, but the splice where scarfing alone is resorted to has the neatest appearance.

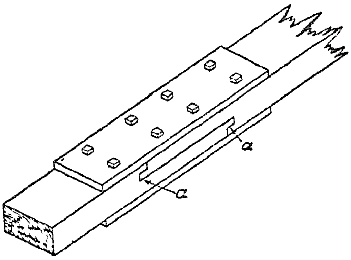


Fig. 44. Halved Splice with Fish Plates.

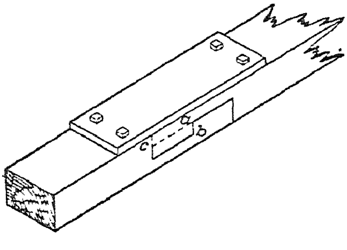


Fig. 45. Splice for Tension.

Splices for Tension. There are several common forms of splices for resisting direct tension. These differ from each other mainly in the amount of labor involved in making them. The simplest of them is shown in Fig. 45, and it will be seen that it is only a slight modification of the halved splice used for resisting compression. It is evident that the pieces cannot pull apart in the direction of their length until the timber crushes along the face marked *a-b*, or shears along the dotted line *a-c*. By varying the dimensions of the splice it may be made suitable for any situation. The parts are held closely together by the light fishplates shown in the figure, which also incidentally add something to the strength of the splice.

Instead of cutting the ends of the beams square, as shown in Fig. 45, they frequently are cut on a bevel as shown in Fig. 46, and a further modification may be introduced by inserting a small "key" of hard wood between the pieces for them to pull against. This key is usually made of oak and may be in two parts, as shown in Fig. 47, each part in the shape of a wedge, so that when they are driven into place a tight joint may be obtained. The two wedge-shaped pieces may be driven in from opposite sides, the hole being made a little smaller than the key. If the key is made much too large for the hole, however, a so-called "initial" stress is brought into the timbers, which uses up some of their strength even before any load is applied. This should be avoided.

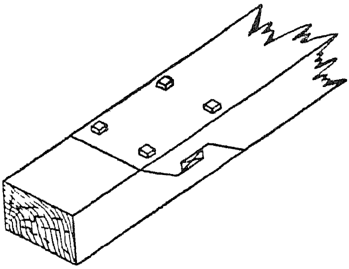


Fig. 46. Splice for Tension.

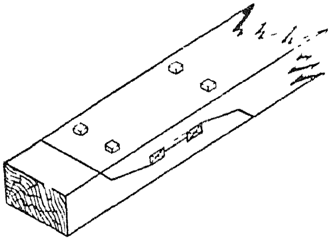


Fig 47. Splice with Two Keys.

If it is desired, two or more keys may be employed in a splice, the only limiting condition being that they must be placed far enough apart so that the wood will not shear out along the dotted line shown in Fig. 47. Another feature of the splice here shown is the way in which the pieces are cut with two bevels on the end instead of one. One bevel starts at the edge of the key and is very gradual, the other starts at the extreme end of the piece and

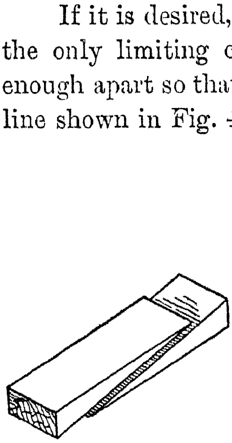


Fig. 48. Keys.

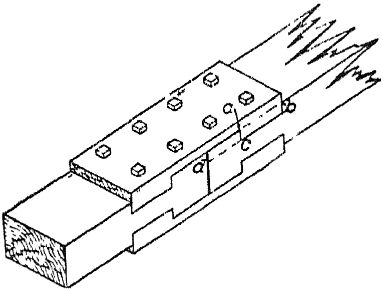


Fig. 49. Tension Splice with Fish Plates.

is rather steep and sharp. These bevels can be used only in joints which resist tension alone. If such a splice were subjected to compression, the beveled ends would slide on each other and push by each other very easily, except as they are prevented from so doing by the fish plates, if these are used.

Tension Splice with Fish Plates. The splices for tension which have so far been described have all been scarf joints, but there is a fished splice which is very commonly used for tension. This splice is shown in Fig. 49. The fish plates, in this case of wood, are cut into the two pieces to be spliced, so as to hold them firmly together. The pieces cannot be pulled apart until one of the plates shears off along the dotted line *a-b*. The distance *c-d* must also be made large enough so that the piece will not shear. This splice is very often used for the lower chords of wooden trusses, and it is really one of the best that can be used for resisting direct tension.

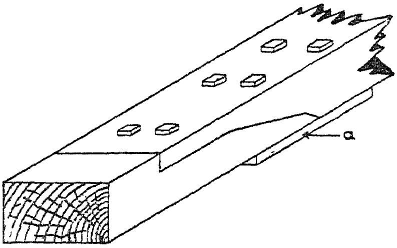


Fig. 50. Splice for Bending.

Splices for Bending. It sometimes happens that a piece which is subjected to a bending stress must be spliced, and in this case the splice must be formed to suit the existing conditions. It is well known that in a timber which is resisting a bending stress the upper part of the piece is in compression, and the tendency is for the fibers to crush, while the lower part of the piece is in tension, and the tendency is for the fibers to pull apart. To provide for this, a form of splice must be selected which combines the features of the tension and compression splices. Fig. 50 shows such a splice. The parts are scarfed together as in the case of the other splices described, but in this case the end of the top piece is cut off square to offer the greatest possible resistance to crushing, while the underneath piece is beveled on the end, as there is no tendency for the timbers to crush. These cuts are shown in the figure.

We have already seen that in the lower part of the splice there is a tendency for the parts to be pulled away from each other. In order to prevent this, a fish plate *a* is used, which must be heavy enough to take care of all the tension, since it is evident that the wood cannot take any of this. The plate must be securely bolted to both parts of the splice. There is no need of a fish plate on the top of the pieces because there is no tendency for the pieces to pull apart on top, and the bolts shown in the figure are sufficient to prevent them from being displaced.

In any case where it is not desirable to scarf the pieces in a splice subjected to bending, the form of butt joint shown in Fig. 51 may be used. The plates (either of wood or iron) are in this case bolted to the sides of the pieces. If wood is used, of course the plates must be made very much heavier than if iron is used. In either case they must be large enough to take care of all the bending stress, and a sufficient number of bolts must be used to fasten them securely to both parts of the splice.

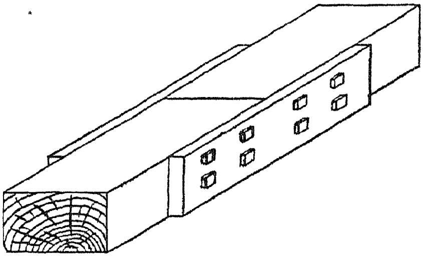


Fig. 51. Butt Joint.

THE WALL.

Let us next consider the framing of the walls of the building. In this work there are two distinct methods known respectively as "braced framing" and "balloon framing," of which the first is the older and stronger method, while the second is a modern development and claims to be more philosophical, as well as more economical, than the other. Balloon framing has come into use only since 1850, and is still regarded with disfavor by many architects, especially in the eastern states. Figs. 52 and 53 show the framing of one end of a small building by each of these methods, the braced framing in Fig. 52, and the balloon framing in Fig. 53.

Braced Frame. In a full-braced frame all the pieces should be fastened together with mortise-and-tenon joints, but this is much modified in common practice, a so-called "combination" frame being used, in which some pieces are mortised together and others are fastened by means of spikes only. A framework is constructed consisting in each wall of the two "corner posts" A A (Fig. 52), the "sill" B, and the "plate" C, together with a horizontal "girt" D at each story, to support the floors, and a diagonal "brace" E at each corner, which, by keeping the corner square, prevents the frame from being distorted.

Balloon Frame. In a balloon frame there are no braces or girts, and the intermediate studs F F F (Fig. 53) are carried straight up from the sill H to the plate K, with a light horizontal piece J, called a "ribbon" or "ledger board," set into them at each floor level to support the floors. This frame depends mainly upon the boarding for its stiffness, but sometimes light diagonal braces are set into the studs at each corner to prevent distortion. The methods by which all these pieces are framed together will be explained in detail under the proper headings.

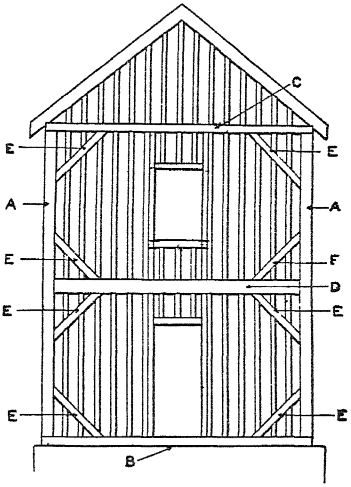


Fig. 52. Braced Frame.

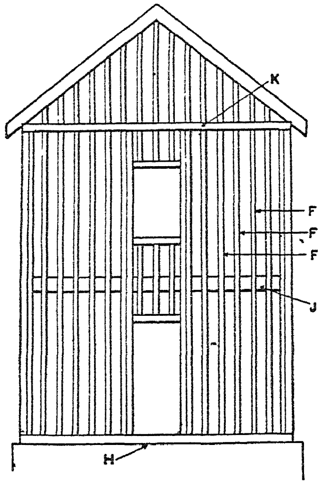


Fig. 53. Balloon Frame.

The Sill. The sill is the first part of the frame to be set in place. It rests directly on the underpinning and extends all around the building, being jointed at the corners and spliced where necessary; and since it is subject to much cutting and may be called upon to span quite considerable openings (for cellar windows, etc.) in the underpinning, it must be of good size. Usually it is made of six by six square timber, but in good work it should be six by eight, and nothing lighter than six by six should be used except for piazza sills. For piazza sills a four by six timber is used. The material is generally spruce, although sometimes it is Norway pine or native pine (depending upon the locality).

The sill should be placed on the wall far enough back from the outside face to allow for the water table, which is a part of the outside finish; and one inch should be regarded as the minimum distance between the outside face of the sill and the outside face of the underpinning (see Fig. 54). A bed of mortar A, preferably of cement mortar, should be prepared on the top of the underpinning, in which the sill C should rest; and the under side of the sill should be painted with one or two coats of linseed oil to prevent it from absorbing moisture from the masonry. In many cases, at intervals of eight or ten feet, long bolts B are set into the masonry. These bolts extend up through holes bored in the sill to receive them, and are fastened at the top by a washer and a nut screwed down tight. They fasten the sill, and consequently the whole frame, securely to the underpinning, and should always be provided in the case of light frames in exposed positions.

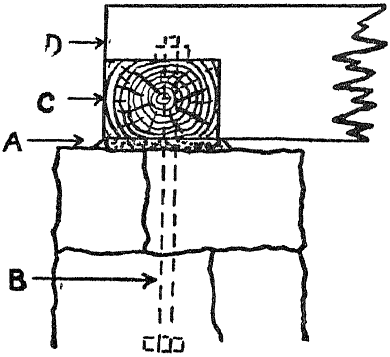


Fig. 54. Sill Placed on Wall.

The beams or "joists" D, which form the framework of the first floor, are supported at one or both ends by the sill and may be fastened to it in any one of several different ways. The ideal method is to hang the joist in a patent hanger fastened to the sill as shown in Fig. 55, where A is the sill, B the joist, and C the hanger. In this case neither the sill nor the joist need be

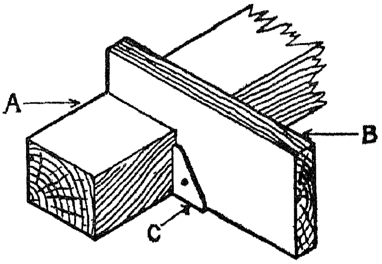


Fig. 55. Patent Hanger.

weakened by cutting, but this is too expensive a method for ordinary work, although the saving in labor largely offsets the cost of the hanger. The usual method is to cut a mortise in the sill to receive a tenon cut in the end of the joist (as shown at A in Fig. 56). These mortises are cut in the inside upper corner of the sill, are about four inches deep and cut two inches into the width of the sill, and are fixed in position by the spacing of the joists.

Mortises are also cut in the sill to receive tenons cut in the lower ends of the studs (as shown at B in Fig. 57). They are cut the full thickness of the studding, about one and one-half inches in the width of the sill and about two inches deep. The position of these is fixed by the spacing of the studding, and by the condition that the outer face of the studding must be flush with the outer face of the sill in order to leave a plain surface for the boarding.

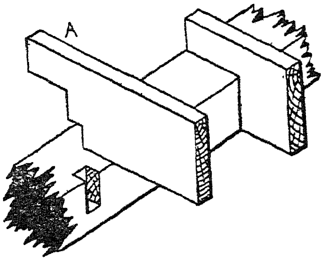


Fig. 56. Mortise in Sill.

The sills are usually halved and pinned together at the corners, as shown in Fig. 58; but sometimes they are fastened together by means of a tenon A cut in one sill, which fits into a mortise cut in the other, as shown in Fig. 59. This may be stronger than the other method, but the advantage gained is not sufficient to compensate for the extra labor involved. Sills under twenty feet in

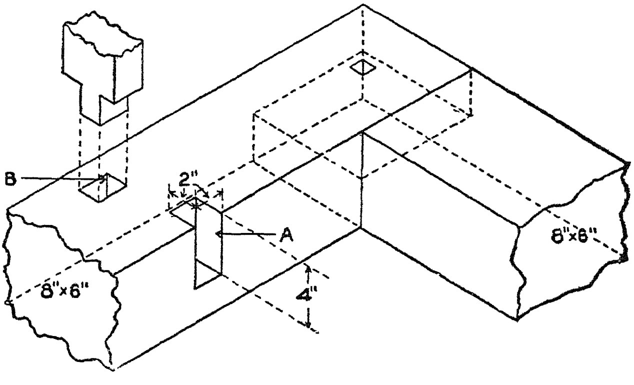


Fig. 57. Mortise in Sill for Studding.

length should be in one piece, but in some cases splicing may be necessary. A scarf joint should always be used, the splice should be made strong, and the pieces should be well fitted together.

In some parts of the country it is customary to "build up" the sill from a number of planks two or three inches thick, which are spiked securely together. A six-by-six-inch sill may be made in this way from three planks, two inches thick and six inches wide, as shown in Fig. 60. Planks of any length may be used, and may be so arranged as to break joints with each other so that the sill may be made continuous, without splicing. It is often easier and cheaper to build up a sill in this way than it is to use a large, solid timber, and if the parts are well spiked together, such a sill is fully as good as the other. When a sill of this kind is used, however, it should always be placed on the wall in such a way that the planks of which it is made up will set up on edge and not lie flat.

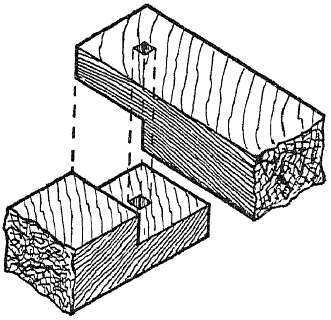


Fig. 58. Joint of Sills at Corner.

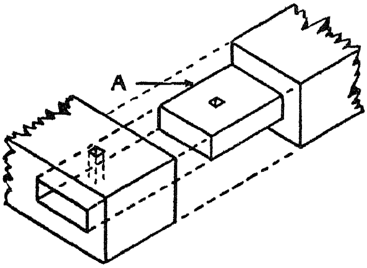


Fig. 59. Joint of Sills at Corner.

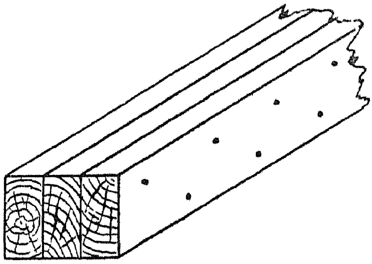


Fig. 60. "Built-up" Sill.

The Corner Posts. After the sill is in place, the first floor is usually framed and roughly covered at once, to furnish a surface on which to work, and a sheltered place in the cellar for the storage of tools and materials, after which the framing of the wall is continued. The corner posts are first set up, then the girts and the plate are framed in between them, with the braces at the corners to keep everything in place; and lastly the whole is filled in with studding. The corner posts are pieces four by eight, or sometimes two pieces four by four placed close together. Corner posts must be long enough to reach from the sill to the plate. The post is really a part of only one of the two walls which meet at the corner, and in the other wall a "furring stud" of two-by-four stuff is placed close up against the post so as to form a solid corner, and give a firm nailing for the lathing in both walls. This arrangement is shown in plan in Fig. 61. A is the corner post, B the furring stud, C the plastering, and D the boarding and shingling on the outside. Sometimes a four-by-four piece is used for the corner post and a two-by-four furring stud is set close against it in each wall to form the solid corner, as shown in plan in Fig. 62; but a four-by-four-stick is hardly large enough for the long corner post, and the best practice is to use a four-by-eight, although in very light framing a four-by-six might be used. A tenon is cut in the foot of the corner post to fit a mortise cut in the sill, and mortises *c c*, Fig. 63, are cut in the post at the proper level to receive the tenons cut in the girts. Holes must also be bored to receive the pins *d d* which fasten these members to the post.

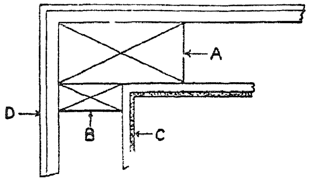


Fig. 61. Corner Post with One Furring Stud.

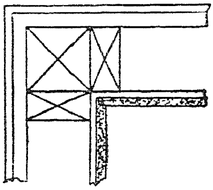


Fig. 62. Corner Post with Two Furring Studs.

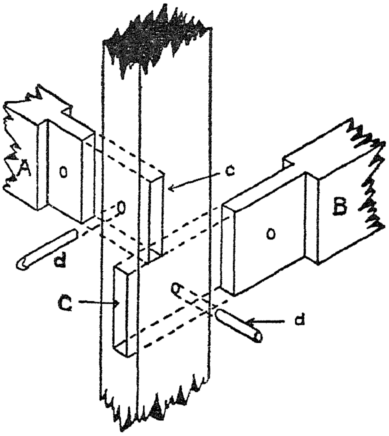


Fig. 63. Mortises in Corner Post.

The braces are often only nailed in place, but it is much better to cut mortises in the posts for these also, as shown at A in Fig. 64. The plate is usually fastened to the posts by means of spikes only, but it may be mortised to receive a tenon cut in the top of the post.

In the case of a balloon frame no mortises need be cut in the posts for the girts or braces, as they are omitted in this frame; but the post must be notched instead, as shown in Fig. 65, to receive the ledger board or ribbon and the light braces which are sometimes used.

The Girts. The girts are always made of the same width as the posts, being flush with the face of the post both outside and inside, and the depth is usually eight inches, although sometimes a six-inch timber may be used. The size is, therefore, usually four by eight. A tenon at each end fits into the mortise cut in the post, and the whole is secured by means of a pin *d d* as shown in Fig. 63. The pin should always be of hard wood and about seven-eighths inch in diameter. It is evident that if the girts in two adjacent walls were framed into the corner post at the same level, the tenons on the two girts would conflict with each other. (See Fig. 63.) For this reason the girts A which run parallel with the floor joists are raised above the girts B on which these joints rest, and are called "raised girts" to distinguish them from the others which are called "dropped girts." The floor joists are carried by the dropped girts, and the raised girts are so placed that they are just flush on top with the joists which are parallel to them.

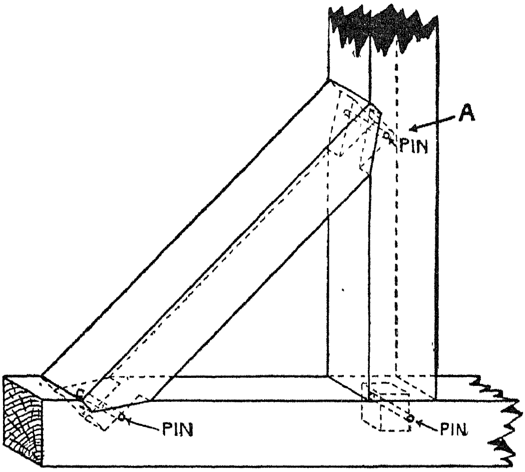


Fig. 64. Brace for Post and Sill.

The Ledger Board. The heavy girts are used only in the braced frame. In the balloon frame, light pieces called "ledger boards" or "ribbons" are substituted for them. These are usually made about one inch thick and six or seven inches deep, and are notched into the posts and intermediate studs instead of being framed into them as in the braced frame. This notching is shown in Fig. 66 in which A is the ledger board and B the stud. The ledger boards themselves are not cut at all, but the floor joists which they carry are notched over them, as shown in Fig. 67, and spiked to them and to the studding. In Fig. 67 A is the joist, B the ledger board, and C the stud.

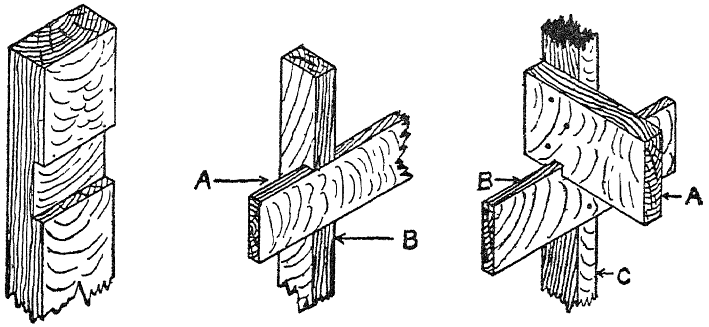


Fig. 65. Fig. 66. Fig. 67.
Notched Studs for Ledger Boards.

Even in the braced frame a ledger board is usually employed to support the joists of the attic floor, which carry little or no weight. The disadvantage of the ledger board is that as a tie between the corner posts it is less effective than the girt, and consequently a wall in which it has been substituted for the girt is not as stiff as one in which the girt is used.

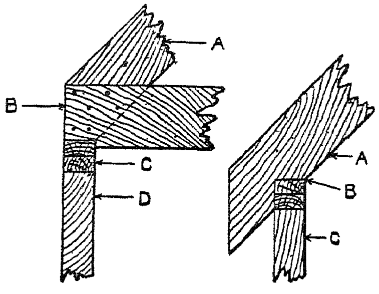


Fig. 68. Fig. 69.
Construction at Plate.

The Plate. The plate serves two purposes: first, to tie the studding together at the top and form a finish for the wall; and second, to furnish a support for the lower ends of the rafters. (See Fig. 68). It is thus a connecting link between the wall and the roof, just as the sill and the girts are connecting links between the floors and the wall. Sometimes the plate is also made to support the attic floor joists, as shown in Fig. 68, in which A is a rafter, B the joist spiked to the rafter, C the plate built up from two two-by-four pieces, and D the wall stud. It acts in this case like a girt, but this arrangement is not very common, the attic floor joists usually being supported on a ledger board as shown in Fig. 67. The plate is merely spiked to the corner posts and to the top of the studding; but at the corner where the plates in two adjacent walls come together, they should be connected by a framed joint, usually halved together in the same way as the sill. In the braced frame, a fairly heavy piece, usually a four by six, is used, although a four by four is probably sufficiently strong. In a balloon frame the usual practice is to use two two-by-four pieces placed one on top of the other and breaking joints, as shown at A in Fig. 70, in order to form a continuous piece. The corner joint is then formed, as shown at B in Fig. 70. No cutting is done on the plate except at the corners, the rafters and the attic floor joists being cut over it, as shown in Figs. 68 and 69.

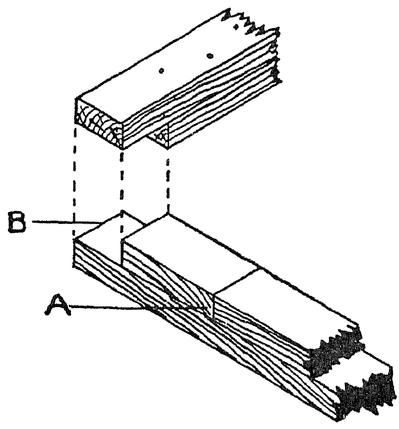


Fig. 70. Construction at Corner, "Breaking Joints."

Braces. Braces are used as permanent parts of the structure only in braced frames, and serve to stiffen the wall, to keep the corners square and true, and to prevent the frame from being distorted by lateral forces, such as wind. In a full-braced frame, a brace is placed wherever a sill, girt, or plate makes an angle with a corner post, as shown at E in Fig. 52. Braces are placed so as to make an angle of forty-five degrees with the post, and should be long enough to frame into the corner post at a height of from one-third to one-half the height of the story. This construction is often modified in practice, and the braces are placed as shown at A in Fig. 71. Such a frame is not quite so stiff and strong as the regular braced frame, but it is sufficiently strong in most cases.

The braces are made the same width as the posts and girts, usually four inches, to be flush with these pieces both outside and inside, and are made of three-by-four or four-by-four stuff. They are framed into the posts and girders or sills, by means of a tenon cut in the end of the brace, and a mortise cut in the post or girt, and are secured by a hard-wood pin. The pin should be three-quarters or seven-eighths inch in diameter. The connection is shown in Fig. 64.

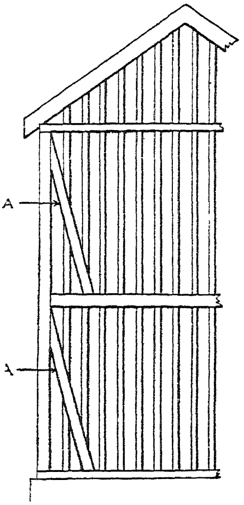


Fig. 71. Braced Frame.

In a balloon frame, there are no permanent braces, but light strips are nailed across the corners while the framework is being erected, and before the boarding has been put on, to keep the frame in place. As soon as the outside boarding is in place these are removed. This practice is also modified, and sometimes light braces are used as permanent parts of even a balloon frame. They are not framed into the other members, however, but are merely notched into them and spiked as shown in Fig. 72. A is the brace, B the sill, C the corner post, and D D are studs. In such a case every stud must be notched to receive the brace, which is really the same as the temporary brace mentioned above, except that it is notched into the studs instead of being merely nailed to them, and is not removed when the boarding is put on. These braces are usually made of one-by-three-inch stuff.

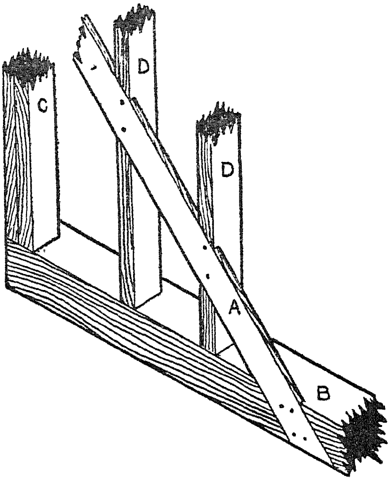


Fig. 72. Temporary Brace.

Studding. When the sill, posts, girts, plates, and braces are in place, the only step that remains to complete the rough framing of the wall is the filling in of this framework with studding. The studding is of two kinds, the heavy pieces which form the frames for the door and window openings, and the stops for the partitions; and the lighter pieces which are merely "filling-in" studs, and which are known by that name, or as "intermediate" studding.

The frames for the door and window openings are usually made in a braced frame, from four-by-four-inch pieces. A vertical stud A A, Fig. 73, is placed on each side of the opening, the proper distance being left between them, and horizontal pieces B B are framed into them at the proper level to form the top and the bottom of the opening. In all good work a small truss is formed above each opening by setting up two pieces of studding C C over the opening, in the form of a triangle. This is to receive any weight which comes from the studding directly above the opening, and carry it to either side of the opening where it is received by the studding and in this way carried down to the sill. Such a truss is shown in Fig. 73. The pieces used are three by four or four by four, and may be either framed into the other members or merely spiked. There should be a space D of at least one inch between the piece B forming the top of the window frame and the piece E forming the bottom of the truss, so that if the truss sags at all it will not affect the window frame. This is a point that is not generally recognized. The piece B is usually made to serve both as the top of the window and the bottom of the truss.

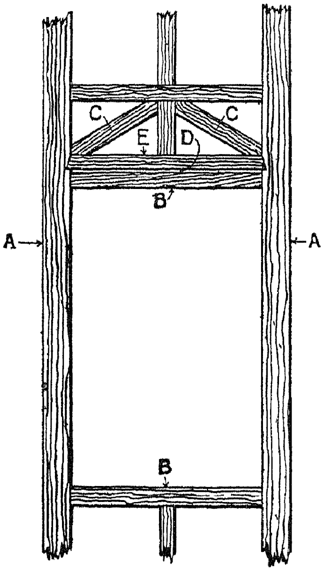
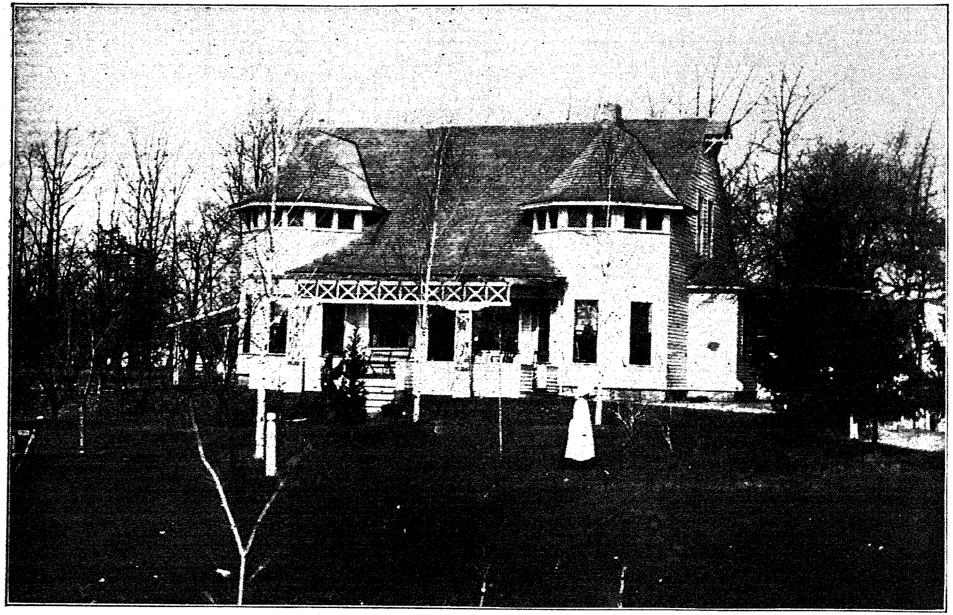


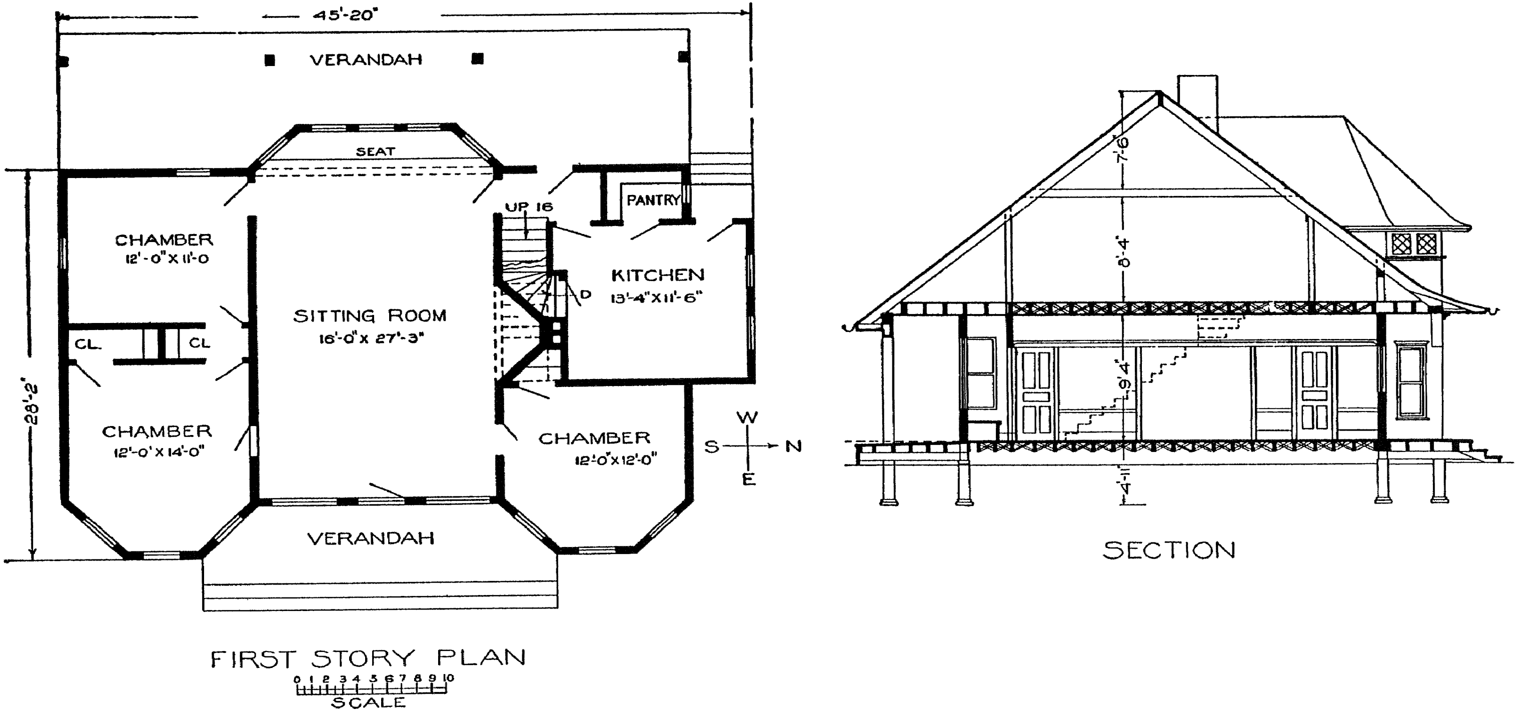
Fig. 73. Truss over Window.

Fig. 74 shows the framing for the top of a window opening in a balloon-framed building, where the ledger-board is partly supported by the studs directly over the opening. Since the floor joists rest on the ledger-board, there may be considerable weight carried onto these studs; and to prevent the bottom of the truss from sagging under this weight, a rod should be inserted as shown.



SUMMER HOME IN MICHIGAN, OF W. CARBYS ZIMMERMAN, ARCHITECT, CHICAGO, ILL.

Frame House with Brick Foundations. Built in 1904.



FIRST STORY PLAN

SECTION

SUMMER HOME IN MICHIGAN, OF W. CARBYS ZIMMERMAN, ARCHITECT, CHICAGO, ILL.

House was Built in 1904, at a Time when the Prices of Material and Labor were at their Lowest It Cost, without Heating and Plumbing, $950. Economy is Greatly Due to the Simplicity of the Roof Construction.

In the balloon frame, the door and window studs are almost always made of two two-by-four pieces placed close together, and in this case the connection of the pieces forming the top and bottom of the frame with those forming the sides is made as shown at A in Fig. 75. It should be noticed that in a balloon frame all studding is carried clear up from the sill to the plate, so that if there is an opening in the wall of the first story, and no corresponding openings in those of the second or third story, the door and window studding must still be carried double, clear up to the plate, and material is thus wasted. In designing for balloon frames, therefore, it is well to take care that the window openings in the second story come directly above those in the first story wherever this is possible. The same difficulty does not occur in the case of a braced frame, because in such a frame the studding in each story is independent of that in the story above or below it, and the openings may be arranged independently in the different stories.

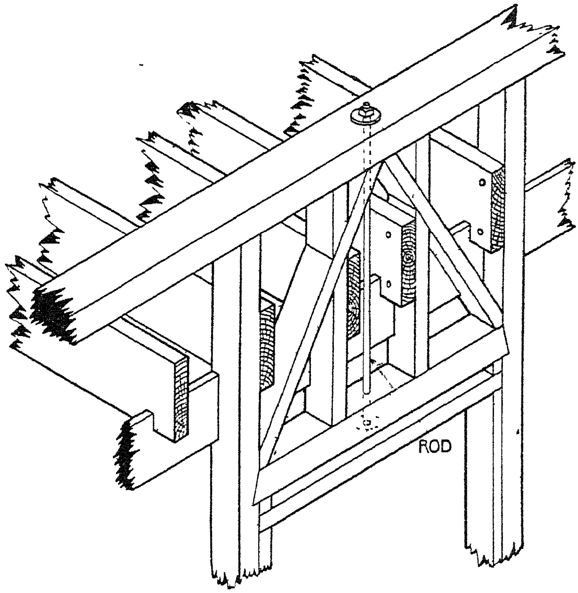


Fig. 74. Truss over Window. Balloon Frame.

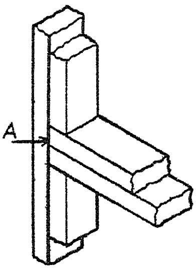


Fig. 75.

Nailing Surfaces. Wherever a partition meets an outside wall, a stud wide enough to extend beyond the partition on both sides and afford a solid nailing for the lathing must be inserted. A nailing surface must be provided for the lathing on both the outside wall and the partition, and the first stud in the partition wall is therefore set close up against the wall stud, forming a solid corner. This arrangement is shown in plan in Fig. 76. The large wall stud A is usually made of a four-by-eight piece set flatwise in the wall so that if the partition is, say, four inches wide, there is a clear nailing surface of two inches on each side of the partition. A four-by-six piece could also be used here, leaving a clear nailing surface of one inch on each side of the partition.

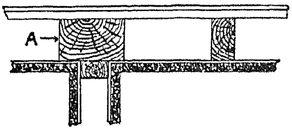


Fig. 76.

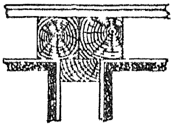


Fig. 77.

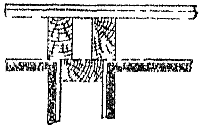


Fig. 78.

Arrangement of Studding for Nailing Surfaces.

Sometimes the same thing is accomplished by using two four-by-four pieces placed close together as shown in plan in Fig. 77, instead of one four-by-eight piece. Sometimes two pieces, two-by-four or three-by-four, are used, placed far enough apart so that they afford a space for nailing on each side of the partition, as shown in plan in Fig. 78. Whenever this is done, small blocks A, Fig. 79, should be cut in between the two studs at intervals of two to three feet throughout their height, to give them added stiffness and make them act together.

The end in view in every case is to obtain a solid corner on each side of the partition where it joins the wall, and any construction which accomplishes this is good. In the best work, however, the four-by-eight solid piece is used, and this construction can always be depended upon. It makes no difference what the angle between the wall and the partition may be, but usually this angle is a right angle.

Intermediate Studding. The pieces which make up the largest part of the wall frame are the "filling-in," or "intermediate" studs. These, as the name implies, are used merely to fill up the frame made by the other heavier pieces, and afford a nailing surface for the boarding, which covers the frame on the outside, and the lathing, which covers it on the inside. The filling-in studs are usually placed sixteen inches apart, measured from the center of one stud to the center of the next. In especially good work they are sometimes placed only twelve inches apart on centers, but this is unusual. In no case should they be placed more than sixteen inches apart, even in the lightest work. The studs are made the full width of the wall, usually four inches, but sometimes in large buildings (such as churches) five or even six inches. They are almost always two inches thick, two by four being the ordinary dimensions for studding, and the lengths are cut to fit the rest of the frame.

In the braced frame, there must necessarily be a great deal of cutting of the intermediate studding, because all the large pieces are made the full width of the wall, and the intermediate studding must be cut to fit between them. In the balloon frame, however, the intermediate studding in all cases extends clear up from the sill to the plate, and no cutting is necessary except the notching to receive the other parts of the frame. (See Fig. 53.)

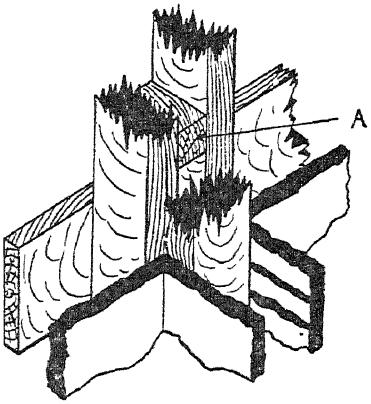
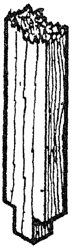


Fig. 79. Wall Studding.

In a balloon frame it often happens that the studs are not long enough to reach from the sill to the plate and they must be pieced out with short pieces which are spliced onto the long stud. This splicing is called "fishing," and it is accomplished by nailing a short, thin strip of wood A A on each side of the stud as shown in Fig. 40 in order to join the two pieces firmly together. The strips should be well nailed to each piece.

All door and window studs should have a tenon cut at the foot of the piece to fit a mortise cut in the sill. Intermediate studs are merely spiked to the sill without being framed into it. The tenons are cut in two different ways, as shown in Figs. 80 and 81. They are always made the full thickness of the piece, and by the first method they are placed in the middle of the piece, as shown. The width of the tenon is about one and one-half inches, leaving an inch and a-half on the outside and one inch on the inside of the stud. Another way is to make the tenon on the inside of the stud, as shown in Fig. 81, the tenon being an inch and a-half wide as before. There is no choice between these two methods, both being good.



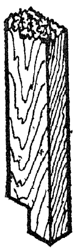


Fig. 80 Tenons for Studs. Fig. 81.

Partitions. The studding used in partition walls is usually of two-by-four stuff, although two-by-three studding may sometimes be used to advantage if the partition does not support any floor joists.

The partition walls are made four inches wide, the same as in the outer walls, except in the case of so-called "furring" partitions. These are built around chimney breasts and serve to conceal the brickwork and furnish a surface for plastering. They are formed by placing the studding flatwise, in order to make a thin wall; and as it is usually specified that no woodwork shall come within one inch of any chimney, a one-inch space is left between the brickwork and the furring wall. It is possible to apply the plaster directly to the brickwork, and this is sometimes done, but there is always danger that cracks will appear in the plastering at the corner A, Fig. 82, between the chimney breast and the outside wall. This cracking is due to the unequal settlement of the brickwork and the woodwork, since the plastering goes with the wall to which it is applied. The method of constructing the furring wall is shown in plan in Fig. 83. A A are the furring studs, B is the plastering, and C C the studding in the outside wall. The arrangement without the furring wall is shown in plan in Fig. 82. If there are any openings in the furring wall such as fireplaces, or "thimbles" for stove pipes, it is necessary to frame around them in the same way as was explained for door and window openings in the outside walls.

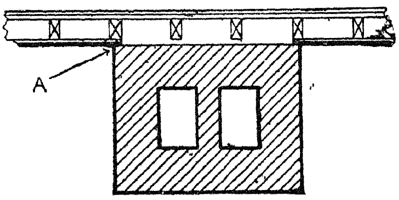


Fig. 82. Plastering around Chimney.

See Fig. 84. A A are furring studs, B B are pieces forming the top and bottom of the opening.

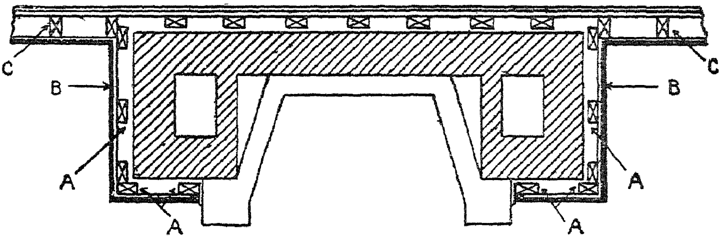


Fig. 83. Furring Wall around Chimney.

Masonry Walls. If the outside walls of the building are of brick or stone, a wooden "furring" wall is usually built just inside of the outer wall; this furnishes a surface for plastering and for nailing the inside finish. The studding for these walls is two-by-four or two-by-three set close up against the masonry wall and preferably spiked to it (see Fig. 85). Spikes are usually driven directly into the mortar between the bricks or stones of the wall, but sometimes wooden blocks or wedges are inserted in the masonry wall to afford a nailing.

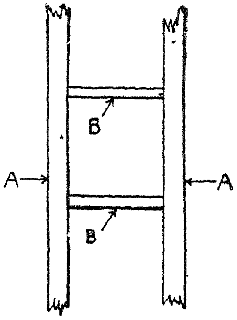


Fig. 84 Opening for Thimble.

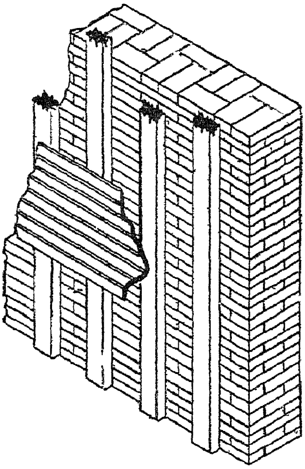


Fig 85 Furring for Brick Wall.

Wherever a wooden partition wall meets a masonry exterior wall at an angle, the last stud of the partition wall should be securely spiked to the masonry wall, to prevent cracks in the plastering.

Cap and Sole. All partition walls are finished at the top and bottom by horizontal pieces, called respectively the cap and the sole. The sole rests directly on the rough flooring whenever there is no partition under the one which is being built; but if there is a partition in the story below, the cap of the lower partition is used as the sole for the one above. The sole is made wider than the studding forming the partition wall, so that it projects somewhat on each side and gives a nailing for the plasterer's grounds and for the inside finish. It is usually made about two inches thick and five and a-half inches wide, when the partition is composed of four-inch studding, and this leaves a nailing surface of three-quarters of an inch on each side. The sole is shown at B in Fig. 86. The cap is usually made the same width as the studding, and two inches thick, so that a two-by-four piece may be used in most cases; but if the partition is called upon to support the floor beams of the floor above, the cap may have to be made three or even four inches thick, and some architects favor the use of hardwood such as Georgia pine for the partition caps. The cap is shown at A, Fig. 87.

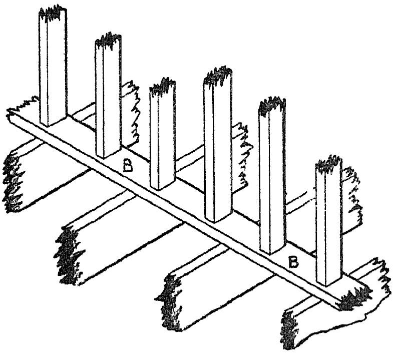


Fig. 86. Sole Piece.

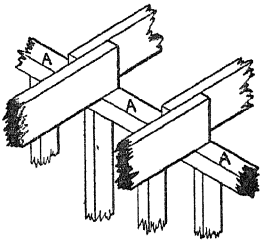


Fig. 87. Partition Cap.

Bridging. In order to stiffen the partitions, short pieces of studding are cut in between the regular studding in such a way as to connect each piece with the pieces on each side of it. Thus, if one piece of studding is for any reason excessively loaded, it will not have to carry the whole load alone but will be assisted by the other pieces. This operation is called "bridging," and there are two kinds, which may be called "horizontal bridging" and "diagonal bridging." The horizontal bridging consists of pieces set in horizontally between the vertical studding to form a continuous horizontal line across the wall, every other piece, however, being a little above or below the next piece as shown in Fig. 88. The pieces are two inches thick and the full width of the studding; and in addition to strengthening the wall, they prevent fire or vermin from passing through, and also may be utilized as a nailing surface for any inside finish such as wainscoting or chair rails.

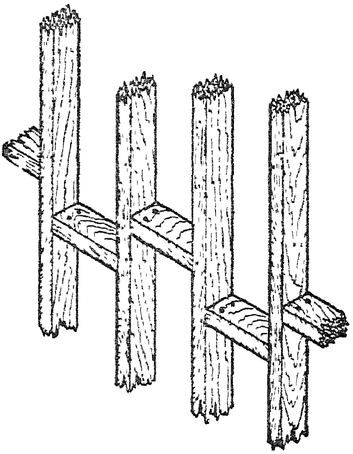


Fig. 88. Horizontal Bridging.

The second method, which we have called diagonal bridging, is more effective in preventing the partition from sagging than is the straight bridging, but both methods may be used with equal propriety. In the diagonal bridging the short pieces are set in diagonally as is shown in Fig. 89, instead of horizontally, between the vertical studding. This method is certainly more scientific than the other, since a continuous truss is formed across the wall.

All partitions should be bridged by one of these methods, at least once in the height of each story, and the bridging pieces should be securely nailed to the vertical studding at both ends. It is customary to specify two tenpenny nails in each end of each piece. Bridging should be placed in the exterior walls as well as in the partition walls; and as a further precaution against fire, it is good practice to lay three or four courses of brickwork, in mortar, on top of the bridging in all walls, to prevent the fire from gaining headway in the wall before burning through and being discovered. This construction is shown in Fig. 90.

Special Partitions. A partition in which there is a sliding door must be made double to provide a space into which the door may slide when it is open. This is done by building two walls far enough apart to allow the door to slide between them, the studding being of two-by-four or two-by-three stuff, and placed either flatwise or edgewise in the wall. If the studding is placed flatwise in the wall, a thinner wall is possible, but the construction is not so good as in the case where the studs are placed edgewise. If the partition is to support a floor, one wall must be made at least four inches thick to support it, and the studs in the other wall may then be placed flatwise if desired, and the floor supported entirely on the thick wall. The general arrangement is shown in plan in Fig. 91. It is better to use two-by-three studding set edgewise in each wall so as to make two three-inch walls with space enough between to allow the door to slide freely after the pocket has been lined with sheathing.

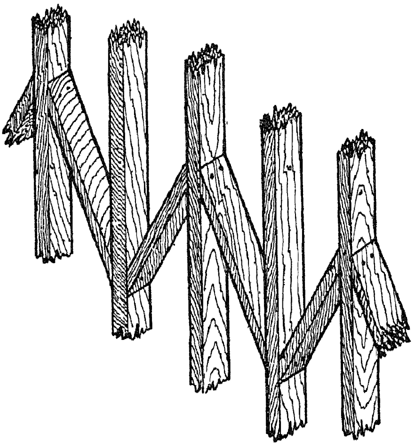


Fig. 89. Diagonal Bridging.

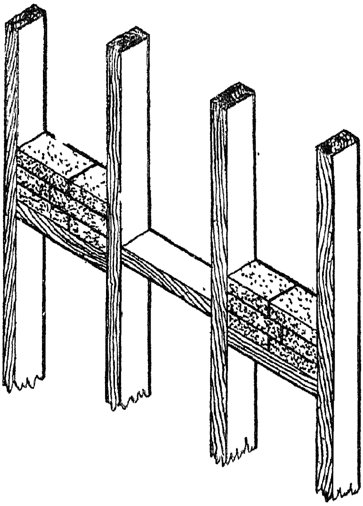


Fig. 90. Brick Work on Bridging.

A piece of studding A, Fig. 92, should be cut in horizontally between each pair of studs B, eight or ten inches above the top of the door, in order to keep the pocket true and square. The pocket should be lined on the inside with matched sheathing C.

It is well known that ordinary partitions are very good conductors of sound; and in certain cases, as in tenement houses, this is objectionable, so that special construction is required. If two walls are built entirely separate from each other, and not touching at any place, the transmission of sound is much retarded; and if heavy felt paper or other material is put in between the walls, the partition is made still more nearly sound-proof. In order to decrease the thickness of such a wall as much as possible, the "staggered" partition is used, in which there are two sets of studding, one for each side of the wall, but arranged alternately instead of in pairs as in the double partition. The arrangement is shown in plan in Fig. 93. The two walls are entirely separate from each other and the felt paper may be worked in between the studs as shown, or the whole space may be packed full of some sound-proof and fireproof material such as mineral wool. There is a so-called "quilting paper" or "sheathing quilt" manufactured from seaweed, which is much used for this purpose. The inside edges of the two sets of studs are usually placed on a line, making the whole wall eight inches thick where four-inch studding is used, and the studs may be placed about sixteen inches on centers in each wall. Each set of studding should be bridged separately.

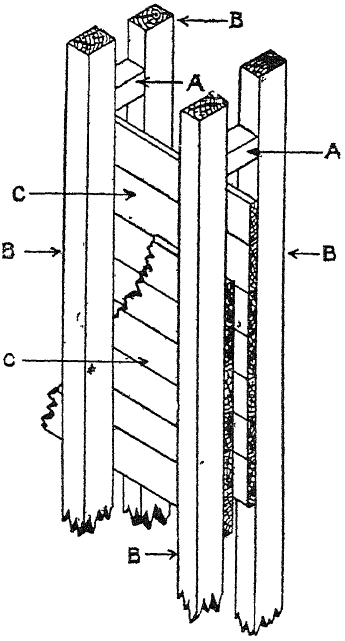


Fig. 92. Double Partition.

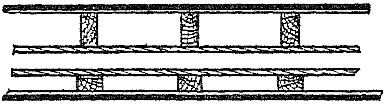


Fig. 91. Double Partition for Sliding Door.

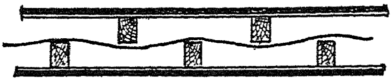


Fig. 93. Sound-proof Partition.

Another case where a double wall may be necessary, is where pipes from heaters or from plumbing fixtures are to be carried in the wall. In case of hot pipes, care must be taken to have the space large enough so that the woodwork will not come dangerously near the pipes.

An important matter in connection with the framing of the partitions is the way in which they are supported; but this involves knowledge of the framing of the floor, and therefore it will be left for the present. It will be taken up after we have considered the floor framing.

Shrinkage and Settlement. An important point which must be considered in connection with the framing of the walls and partitions, is the settlement due to the shrinkage of timber as it seasons after being put in place. Timber always shrinks considerably *across* the grain, but very little in the direction of the grain; so it is the horizontal members such as the sills, girts, and joists which cause trouble, and not the vertical members such as the posts and studding. Every inch of horizontal timber between the foundation wall or interior pier and the plate is sure to contract a certain amount, and as the walls and partitions are supported on these horizontal members, they too must settle somewhat. If the exterior and interior walls settle by exactly the same amount, no harm will be done, since the floors and ceilings will remain level and true as at first; but if they settle unequally, all the levels in the building will be disturbed, and the result will be cracking of the plastering, binding of doors and windows, and a general distortion of the whole frame. This must be avoided if possible.

It is evident that one way to prevent unequal settlement, so far at least as it is due to the shrinkage of the timber, is to make the amount of horizontal timber in the exterior and interior walls, equal. Thus, starting at the bottom, we have from the masonry of the foundation wall to the top of the first-floor joists in the outside walls, ten inches, or the depth of the joists themselves, since these rest directly on the top of the wall. In the interior we have, if the joints are framed flush into a girder of equal depth, the same amount, so that here the settlement will be equal. But the studding in the exterior wall rests, not on the top of the joists, but on the top of the six-inch sill, while the interior studding rests on top of the ten-inch girder. Here is an inequality of four inches which must be equalized before the second floor level is reached. If the outer ends of the second-floor joists rest on the top of an eight-inch girt, and the inner ends on a four-inch partition cap, this equalizes the horizontal timber inside and outside, and the second floor is safe against settlement. The same process of equalization may be continued to the top of the building, and if this is done it will go far toward preventing the evils resulting from settlement and shrinkage.

With a balloon frame this cannot be done, because there are no girts in the outside walls, but only ledger-boards which are so fastened that they cannot shrink, while in the interior walls we have still the partition caps. All that can be done in this case is to make the depths of the sills and interior girders as nearly equal as possible, and to make the partition caps as shallow as will be consistent with safety.

THE FLOORS.

After the wall, the next important part of the house frame to be considered is the floors, which are usually framed while the wall is being put up and before it is finished. They must be made not only strong enough to carry any load which may come upon them, but also stiff enough so that they will not vibrate when a person walks across the floor, as is the case in some cheaply-built houses. The floors are formed of girders and beams, or "joists," the girders being large, heavy timbers which support the lighter joists when it is impossible to allow these to span the whole distance between the outside walls.

Girders are generally needed only in the first floor, since in all the other floors the inner ends of the joists may be supported by the partitions in the floor below. They are usually of wood, though it may sometimes be found economical to use steel beams in large buildings. Wrought iron was once used, but steel is now cheaper and has taken the place of wrought iron. It is rarely, however, that this will be found expedient, and hard pine girders will answer very well in most cases. The connections used in the case of steel girders will be explained later. The girders may be of spruce or even of hemlock, but it is hard to get the hemlock in such large sizes as would be required for such girders, and spruce, too, is hardly strong enough for the purpose. Southern pine, therefore, is usually employed for girders in the best work.

The size of the girder depends on the span, or the distance between the supporting walls, and upon the loads which the floor is expected to carry. In general, the size of a beam or girder varies directly as the length of the span, so that if we have two spans, one of which is *twice* as great as the other, the girder for the longer span should be *twice* as strong as the girder for the smaller span. In ordinary houses, however, all the girders are made about eight by twelve inches in section, although sometimes an eight-by-eight timber would suffice, and sometimes perhaps a twelve-inch piece would be required.

It should be remembered in deciding upon the size of this piece, that any girder is increased in strength in direct proportion to the *width* of the timber (that is, a girder 12 inches wide is twice as strong as one 6 inches wide), but in direct proportion also to the *square of the depth* (that is, a girder 12 inches deep is four times as strong as one 6 inches deep). Hence the most economical girder is one which is deeper than it is wide, such as an eight-by-twelve stick; and the width may be decreased by any amount so long as it is wide enough to provide sufficient stiffness, and the depth is sufficient to enable the piece to carry the load placed upon it. If the piece is made too narrow in proportion to its depth, however, it is likely to fail by "buckling," that is, it would bend as shown in Fig. 94. The width should be at least equal to one-sixth of the depth.

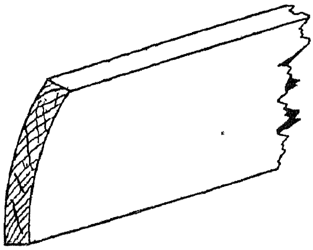


Fig 94.

There are at least three ways in which the joists may be supported by the girder. The best but most expensive method is to support the ends of the joists in patent hangers or stirrup irons which connect with the girder. This method is the same as was described for the sill, except that with the girder a double stirrup iron, such as that shown in Fig. 95, may be used. These stirrup-iron hangers are made of wrought iron, two and one-half or three inches wide, and about three-eighths of an inch thick, bent into the required shape. They usually fail by the crushing of the wood of the girders, especially when a single hanger, like that shown in Fig. 96, is used. Fig. 97 shows a double stirrup-iron hanger in use. Patent hangers as shown in Fig. 98 are by far the best.

If hangers of any kind are used, there will be no cutting of the girder except at the ends where it frames into the sill, and even there a hanger may be used. The girder may be placed so that the joists will be flush with it on top, or so that it is flush with the sill on top. If the joists are flush with the girder on top, and are framed into the sill in the ordinary way, as shown in Fig. 99, the girder cannot be flush on top with the sill; while, on the other hand, if the girder is flush with the sill on top, it cannot at the same time be flush with the joists on top. If joist hangers are used on the girder to support the joists, they will probably be used on the sill as well, as explained in connection with the sill; and in this case the girder can be made flush with the sill on top and the joists hung from both girder and sill with hangers, thus bringing both ends of the joist at the same level, as shown in Fig. 100. If the girder is framed into the sill at all, it would almost

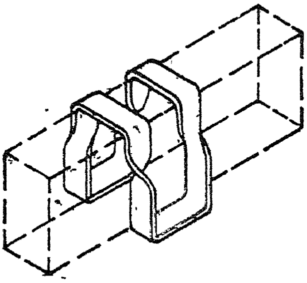


Fig. 95.

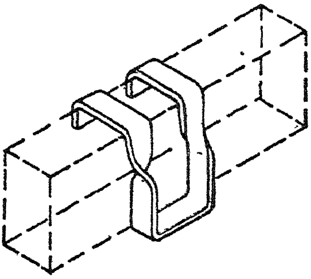


Fig. 96.

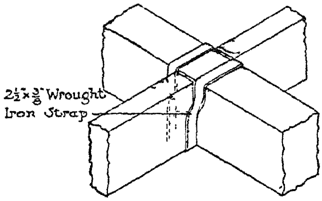


Fig 97.

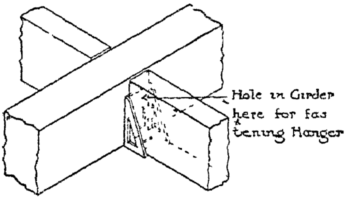


Fig. 98.

always be made flush with the sill on top, and the joists would be arranged so as to be level.

For framing the girder into the sill, a tenon-and-tusk joint, as shown in Fig. 101, would be used if the girder is to be flush with the sill on top. Since the girder would in most cases be deeper than the sill, the latter having a depth of only six inches, the wall would necessarily have to be cut away in order to make a place for the girder. This condition is clearly shown in Fig. 102. The girder itself should not be cut over the wall as shown in Fig. 103, because this greatly weakens the girder. If this method is used, the joists should be framed into the girder in the same way as they are framed into the sill, a mortise being cut in the girder and a tenon on the joist. This is called "gaining" and is shown in Fig. 99. The top of the girder thus comes several inches below the top of the floor.

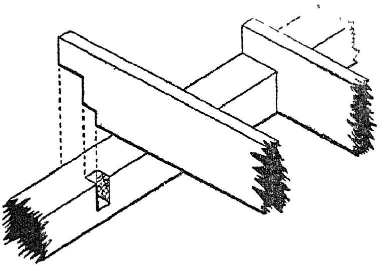


Fig. 99. Framing of Joist into Sill.

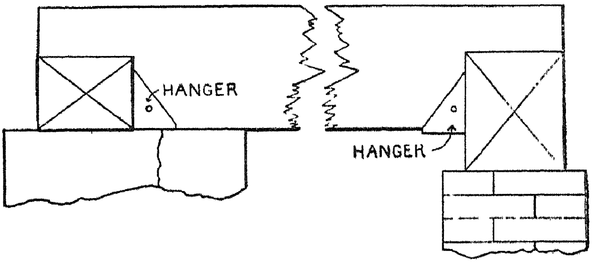


Fig. 100. Use of Hangers.

Another method is to make the top of the girder flush with the top of the joists. The joists are then framed into the girder with a tenon-and-tusk joint, as shown in Fig. 101, and the girder is "gained" into the sill as shown in Fig. 99.

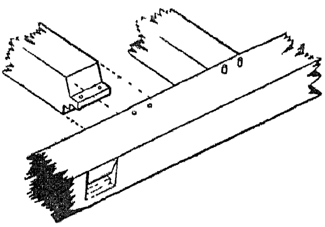


Fig. 101. Framing of Girder into Sill.

Still another method in common use is simply to "size down" the joists on the girder about one inch, as shown in Fig. 104. In this case, of course, the girder is much lower than the sill, usually so low that it cannot be framed into the sill at all, but must be supported by the wall independently. Holes are left in the wall where the girders come, the latter being run into the holes, and their ends resting directly on the wall, independent of the sill.

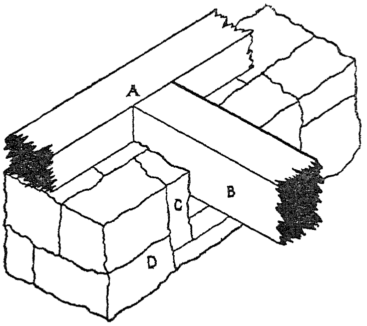


Fig. 102. Framing of Girder into Sill.

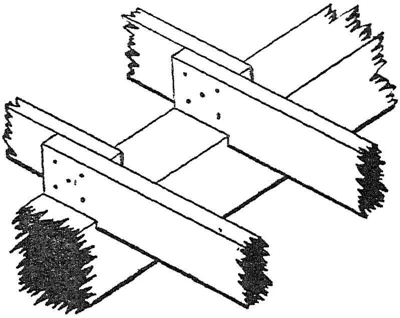


Fig. 104. Joists "Sized Down."

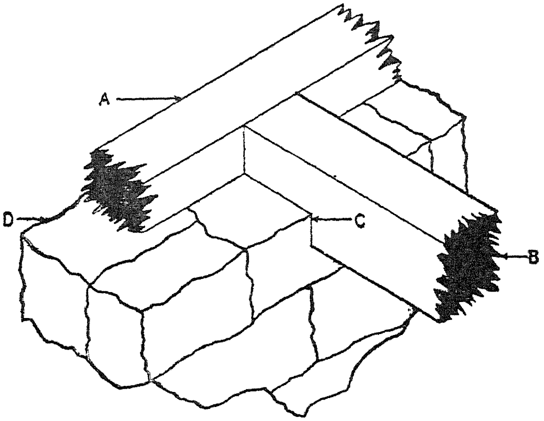


Fig. 103. Framing of Girder into Sill.

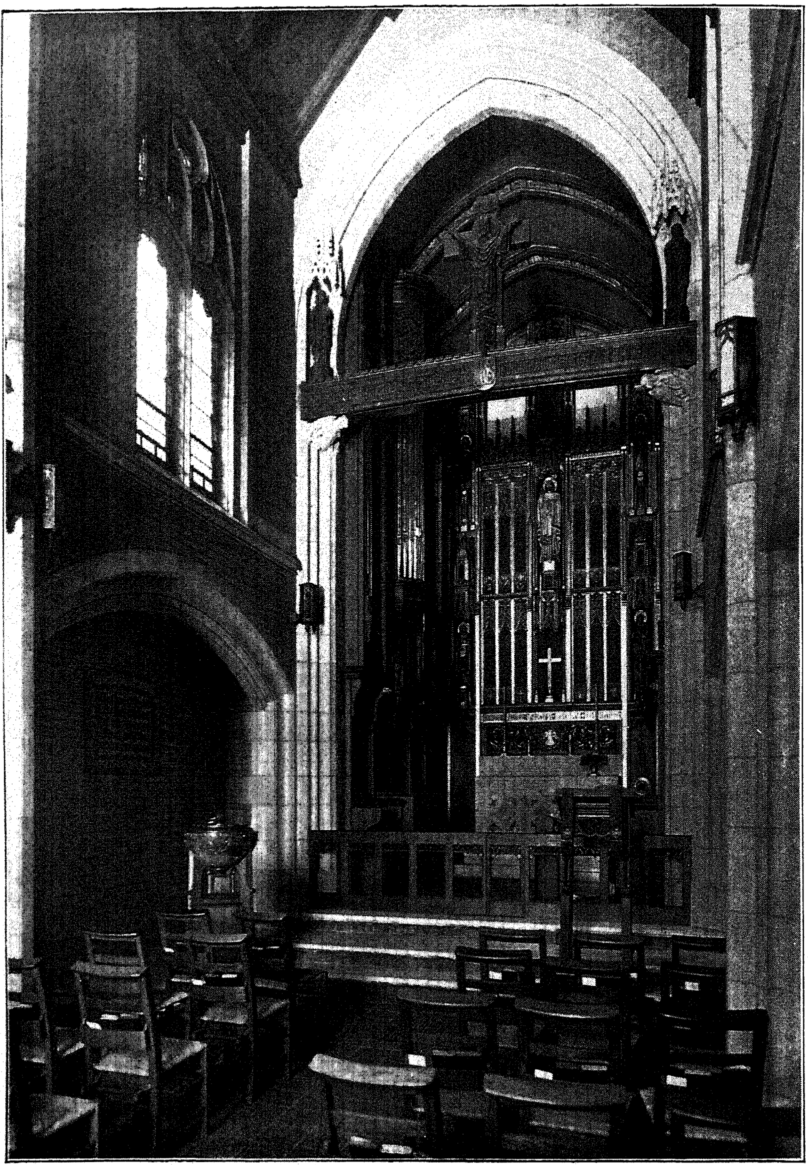
This is not very good construction, however, because the floor is not tied together as it is when the girder frames into the sill. The first method is the best and is the one in most common use.

The girders serve to support the partitions as well as to support the floors, and should therefore be designed to come under the partitions whenever this is possible. When the dista between the outside walls is too great to be spanned by the girc it is supported on brick piers or posts of hardwood or cast iror the cellar. Such piers or posts should always be placed where girders running in different directions intersect each otl Girders are often supported also on brick partitions built in cellar.

Joists are the light pieces which make up the body the floor frame and to which the flooring is nailed. They almost always made of spruce, although other woods may be us and may be found more economical in some localities. They usually two inches thick, but the depth is varied to suit the c ditions. Joists as small as two-by-six are sometimes used in v light buildings, but these are too small for any floor. They r sometimes be used for a ceiling where there are no rooms abc and therefore no weight on the floor. A very common size joists is two-by-eight, and these are probably large enough any ordinary construction, but joists two-by-ten make a sti floor, and are used in all the best work. Occasionally joists large as two by twelve are used, especially in large city hou and they make a very stiff floor, but this size is unusual.] joist deeper than twelve inches is used, the thickness should increased to two and one-half or three inches, in order to prev it from failing by buckling as explained in connection with girders. The size of the joists depends in general upon the s and the spacing.

The usual spacing is sixteen or twenty inches between ters, and sixteen inches makes a better spacing than twenty inc because the joists can then be placed close against the studdin the outside walls and spiked to this studding. It is gener better to use light joists spaced sixteen inches on centers thai use heavier ones spaced twenty inches on centers. The spacin seldom less than sixteen inches and never more than twe inches.

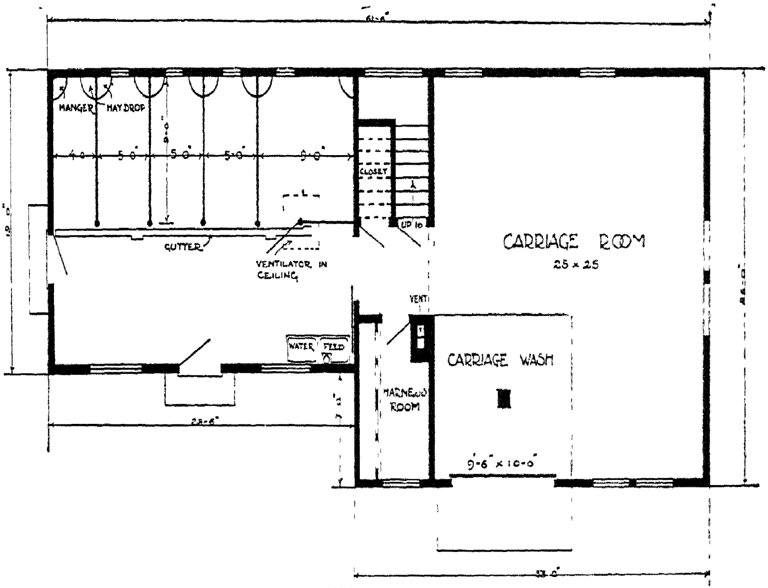
Supports for Partitions. In certain parts of the floor fr it may be necessary to double the joists or place two of them v close together in order to support some very heavy concentra load. This is the case whenever a partition runs parallel v



GRACE MEMORIAL CHAPEL, CHICAGO, ILL.

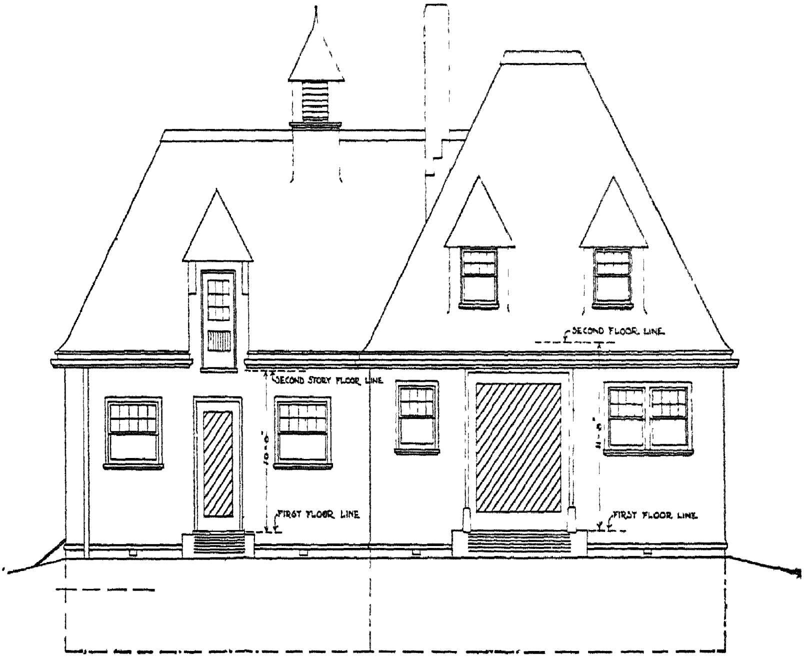
Cram, Goodhue & Ferguson, Architects, Boston and New York.

Interior of Gray Pressed Brick; Trimmings of Terra-Cotta of Color and Finish Similar to Bedford Stone. Floor of 9-in. Welsh Quarries; Chancel Floor of Mercer Tile. For Exterior, See Vol. I, Page 10; for Detail of Wood-Carving, See Vol. II, Page 10.



FIRST FLOOR PLAN

SCALE 0 1 2 3 4 5 6 7 8 9 10 FEET



SOUTH ELEVATION

STABLE FOR MR. J. S. HANNAH, LAKE FOREST, ILL.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

For Location, See Vol. I, Page 74, for Exterior and Plans of House, See Vol. I, Pages 74 and 90.

the floor joists, unless it has another partition under it. Such partitions may be supported in several different ways: A very heavy joist, or two joists spiked together, may be placed under the partition, as shown at A in Fig. 105. In this figure, C is the sole, B the under or rough flooring, and D, D, D the studding. This method is objectionable for two reasons: It is often found convenient to run pipes up in the partition, and if the single joist is placed directly under the partition this cannot be done except by cutting the joist and thus weakening it. Moreover, if the single joist is used, there is no solid nailing for the finished upper flooring, unless the joist is large enough to project beyond the partition studding on each side. The joist is seldom, if ever large enough for this, and the finished flooring must therefore be nailed only to the under flooring at the end where it butts against the partition, so that a weak, insecure piece of work is the result. This may be seen by referring to the figure.

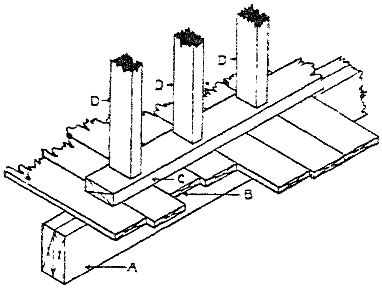


Fig 105. Joists Supporting Partition.

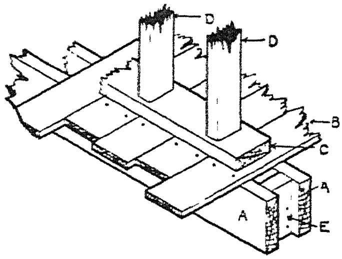


Fig 106.

A much better way is to use two joists far enough apart to project a little on each side of the partition, as shown at A, A in Fig. 106, and thus afford a nailing for the finished flooring. These joists must be large enough to support the weight of the partition without sagging any more than do the other joists of the floor, and therefore joists three or even four inches thick should be used. They should be placed about six or seven inches apart on centers, and plank bridging should be cut in between them at intervals of from fourteen to twenty inches (as shown at E in Fig. 106), in order to stiffen them and make them act together. This plank bridging should be made of pieces of joist two inches thick and of the same depth as the floor joists, and should be so placed that the grain will in every case be horizontal.

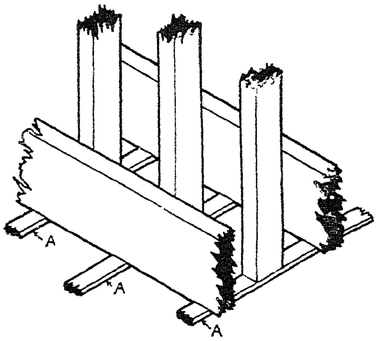


Fig 107. Partition Supported by Strips.

A partition supported as described above is bound to settle somewhat as the ten or more inches of joist beneath it shrinks in seasoning, and the settlement may cause cracks in the plastering at the corner between the partition and an outside wall. In order to prevent this settlement, partitions running parallel with the floor joists are often supported on strips which are nailed to the under side of the floor joists, as shown at A in Fig. 107. These strips cannot be allowed to project into the room below, and so they must be made as thin as possible consistent with safety. Strips of iron plate about one-half inch thick, and wide enough to support the partition studs, are therefore used for this purpose, and are fastened to the joists by means of bolts or lag screws. Partitions which run at right angles to the floor joists can also be supported in this way. If a partition runs at right angles to the joists near the center of their span, the tendency for the joists to sag under it will be very great, and they must be strengthened either by using larger joists, or by placing them closer together. If the span of the floor joists is large and the partition is a heavy one, it may be necessary to put in a girder running at right angles to the joists to carry the partition. In this case the partition studs will set directly on the girder, which may be a large timber, or in some cases, a steel I-beam.

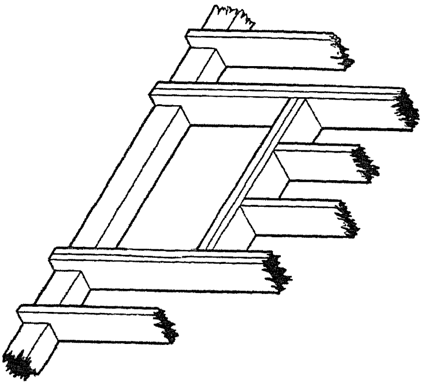


Fig. 108. Headers and Trimmers.

Headers and Trimmers. Another case where a girder may be necessary in a floor above the first, is where an opening is to be left in the floor for a chimney or for a stair well. The timbers on each side of such an opening are called "trimmers," and must be made heavier than the ordinary joists; while a piece called a "header" must be framed in between them to receive the ends of the joists, as shown in Fig. 108. The trimmers may be made by simply doubling up the floor joists on each side of the opening, or, if necessary, I-beams or heavy wooden girders may be used. In most cases these trimmers may be built up by spiking together two or three joists, and the header may be made in the same way.

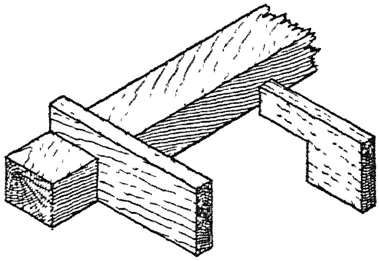


Fig. 109. Connection of Joist to Sill.

Joist Connections. Joists are also "gained" into the sill as shown in Fig. 56, in which case a mortise is cut in the sill and a corresponding tenon is cut in the end of the joist. The mortise was illustrated and described in connection with the sill, while the end of the joist is cut as shown in Fig. 56, the tenon being about four inches deep and gained into the sill about two inches. This brings the bottom of the joist flush with the bottom of the sill, and the top of the joist somewhat above the top of the sill, according to the depth of the joist. The top of a ten-inch joist would come four inches above the top of a six-inch sill, and the joist would rest partly on the masonry wall as shown in Fig. 100, thus relieving the connection of a part of the stress due to the weight of the loaded joist. A common but very bad method of framing the joist to the sill is simply to "cut it over" the sill without mortising the latter, as shown in Fig. 109. This does not make a strong connection even when the joist rests partly on the masonry wall; and if it is not so supported it is almost sure to fail by splitting, as shown in Fig. 110, under a very small loading. In fact, it would be much stronger if the joist were turned upside

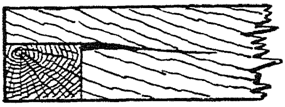


Fig. 110.

down. Frequently the joist is cut as shown in Fig. 111, where the tenon is sunk into a mortise cut in the sill, thus bringing the top of the joist flush with the top of the sill; but in this case the bottom of the joist will almost invariably drop below the bottom of the sill, and the wall must be cut away to make room for it, as shown in Fig. 102. It is also weak in the same way as is the connection shown in Fig. 110.

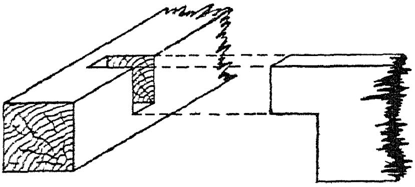


Fig. 111. Joist Mortised into Sill.

The framing of the joists into the girders may be accomplished in several different ways, according to the position of the girder. This placing of the girder is quite an important point. The top of the floor, on which rest the sole-pieces of the cross-partitions, must remain always true and level, that is, the outside ends of the joists must be at the same level as the inside ends. Otherwise the doors in the cross-partitions will not fit their frames, and cannot be opened or shut, and the plastering is almost sure to crack. Both ends of the joists will sink somewhat, on account of the shrinkage of the timber in seasoning, and the only way to make sure that the shrinkage at the two ends will be the same is to see that there is the same amount of *horizontal* timber at each end between the top of the floor and the solid masonry. This is because timber shrinks very much *across* the grain, but almost not at all *along* the grain. If the joist is framed properly into the sill, so that it is flush on the bottom with the sill, we have at the outer end of the joist a depth of horizontal timber equal to the depth of the joist itself, as shown in Fig. 100; and in order to have the same depth of timber at the inside, the bottom of the joist must be flush with the bottom of the girder, which usually rests on brick piers. Of course the top of the girder must not in any case come above the tops of the floor joists; therefore, in general, the

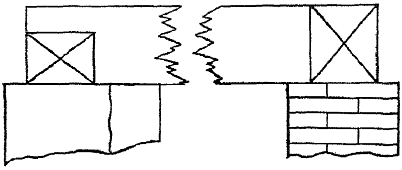


Fig. 112. Joist Framed into Girder.

girder must be equal in depth to the floor joists and flush with these joists on top and bottom, as shown in Fig. 112. This method is not always followed, however, in spite of its evident superiority; and the girder is often sunk several inches below the tops of the floor joists, as shown in Fig. 100, or even in some cases very much below, as shown in Fig. 113. Both of these methods cause an unsightly projection below the ceiling of the cellar. Where the joists are brought flush with the girder top and bottom, they may be framed into it with a tenon-and-tusk joint, the joists being cut as shown in Fig. 101, with a tenon as there shown, and a hole bored through the tenon to receive a pin to hold the joist in place.

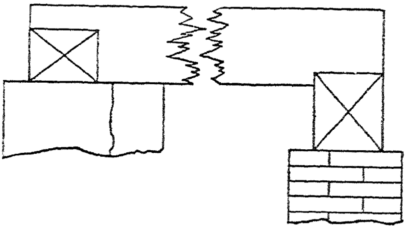


Fig. 113. Joist Sized Down on Girder.

Other methods of framing tenon-and-tusk joints are shown in Figs. 33, 34, and 35, and also a double-tenon joint in Fig. 36, which might be used in this case, although it is much inferior to the tenon-and-tusk joint. Two joists framing into a girder from opposite sides should be fastened strongly together, either by an iron strip passing over the top of the girder and secured to each joist, as shown in Fig. 114, or by means of a "dog" of round bar iron, which is bent at the ends and sharpened so that it may be driven down into the abutting ends of the joists, as shown in Fig. 115. These bars should be used at every fifth or sixth joist, to form a series of continuous lines across the building from sill to sill.

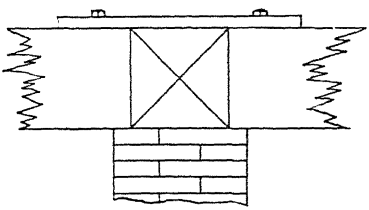
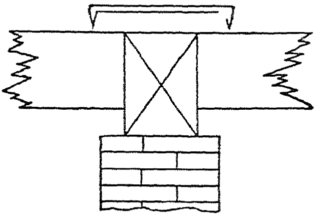



Fig. 114. Use of Straps and Dogs. Fig. 115.

If the girder is sunk a little below the tops of the joists, these may be gained into it in the same way as they are gained into the sill. In this case joists should be arranged as shown in Fig. 116, so that they will not conflict with one another; and the two adjacent joists may be spiked together, thus giving additional stiffness to the floor. If the tenon-and-tusk connection is used, the joists may be arranged exactly opposite each other, provided that the girder is sufficiently wide, but it is always much better to arrange them as shown in Fig. 117, even in this case. The tenon may then be carried clear through the girder and fastened by a dowel, as shown. Very rarely a simple double-tenon joint, such as that shown in Fig. 36, might be used, but it is much inferior to either the gaining or the tenon-and-tusk joint.

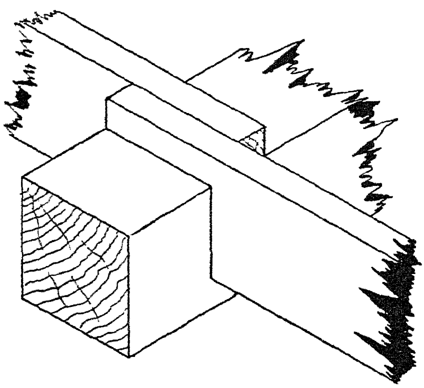


Fig. 116. Joists Framing over Girder.

If the girder is sunk very much below the tops of the joists, as in Fig. 113, these will usually rest on top of it and be fastened by spikes only, or will be "sized down" upon it about one inch, as shown. There is no mortising of the girder in either case. Joists are also thus sized down upon the girts and partition caps, and are notched over the ledger-boards as shown in Fig. 67. In cutting the joists for sizing and notching, the measurements should be taken in every case from the *top* of the joists, since they may not all be of exactly the same depth, and the tops must all be on a level after they are in place. This is really the only reason why the joists should be sized down at all, because otherwise they might simply rest upon the girder, or girt, and be fastened by nailing.

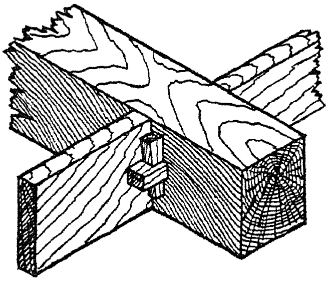


Fig. 117.

Connection to Brick Wall. When a joist or girder is supported at either end on a brick wall, there will either be a hole left in the wall to receive it, or the wall will be corbeled out to form a seat for the beam. If the beam enters the wall the end should be cut as shown in Fig. 118, so that in case of the failure of the beam from overloading or from fire, it may fall out without injuring the wall. Every fifth or sixth joist is held in place by an anchor (as shown in Fig. 119), of which there are several kinds on the market. Fig. 120 shows the result when a beam which is cut off square on the end, falls out of the wall.

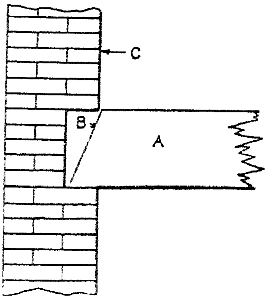


Fig. 118. Joist Supported by Brick Wall.

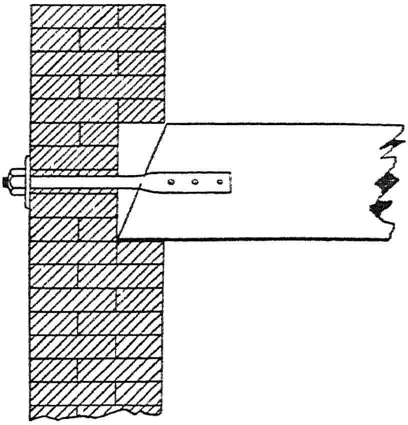


Fig. 119. Use of Anchor.

There must always be left around the end of a beam which is in the wall a sufficient space to allow for proper ventilation to prevent dry rot, and the end should always be well painted to keep out the moisture. Patent wall-hangers and box anchors are often used to support the ends of joists in brick buildings, but only in case of heavy floors.

The floor framing in a brick building is the same as that in a building of wood except that there is no girt to receive the ends of the floor boards, so that a joist must be placed close against the inside of the wall all around the building to give a firm nailing for the flooring.

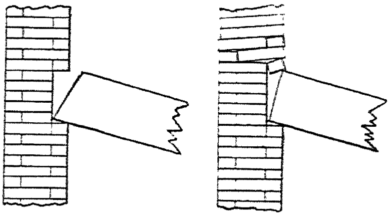


Fig. 120.

Crowning. In any floor, whether in a wood or a brick building, if the span of the floor joists is very considerable so that there is any chance for deflection they must be "crowned" in order to offset the effect of such deflection. The operation called "crowning" consists in shaping the top of each joist to a slight curve, as shown in Fig. 121 B, so that it is an inch or so higher in the middle than it is at the ends. As the joist sags or deflects, the top becomes level while the convexity will show itself in the bottom as shown in Fig. 121 A. Joists need not be crowned unless the span is quite large and the loads heavy enough to cause a deflection of an inch or more at the center of the joist.

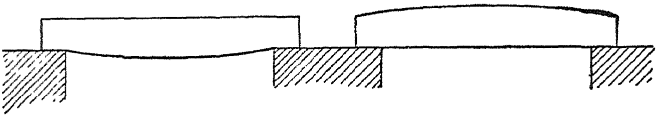


Fig. 121A. Crowning. Fig. 121B.

Bridging. Floor frames are "bridged" in much the same way as was described for the walls, and for much the same purpose, namely, to stiffen the floor frame, to prevent unequal deflection of the joists, and to enable an overloaded joist to get some assistance from the pieces on either side of it. Bridging is of two kinds, "plank bridging" and "cross bridging," of which the first has already been shown in connection with the partition supports. Plank bridging is not very effective for stiffening the floor, and cross bridging is always preferred. This bridging is somewhat like the diagonal bridging used in the walls, and consists of pieces of scantling, usually one-by-three or two-by-three in size, cut in diagonally between the floor joists. Each piece is nailed to the top of one joist and to the bottom of the next; and two pieces which cross each other are set close together between the same two joists, forming a sort of St. Andrew's cross, whence we get the name "cross bridging," or "herring-bone bridging" as it is sometimes called. The arrangement is shown in Fig. 122, and the bridging should be placed in straight lines at intervals of eight or

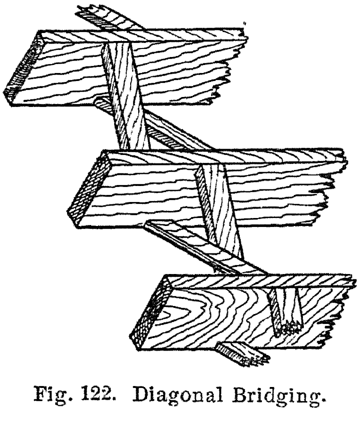


Fig. 122. Diagonal Bridging.

ten feet across the whole length of the floor. Each piece should be well nailed with two eightpenny or tenpenny nails in each end. If this is well done there will be formed a kind of continuous truss across the whole length of the floor which will prevent any overloaded joist from sagging below the others, and which will greatly stiffen the whole floor so as to prevent any vibration. The bridging, however, adds nothing to the strength of the floor.

Porch Floors. A word might appropriately be inserted at this point in regard to the floors of piazzas and porches. These may be supported either on brick piers or on wooden posts, but preferably on piers, as these are much more durable than posts. If piers are used, a sill, usually four by six in size, should be laid on the piers all around, and light girders should be inserted between the piers and the wall of the house in order to divide the floor area into two or three panels. The joists may then be framed parallel to the walls of the house, and the floor boards laid at right angles to these walls. The whole frame should be so constructed that it will pitch outward, away from the house at the rate of one inch in five or six feet, thus bringing the outside edge lower than the inside edge and giving an opportunity for the water to drain off.

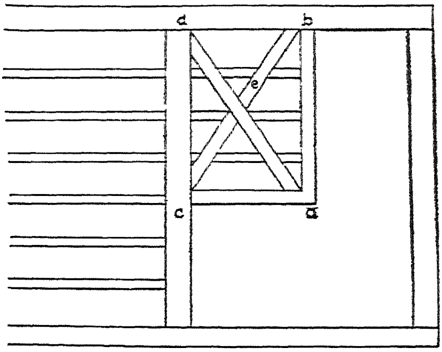
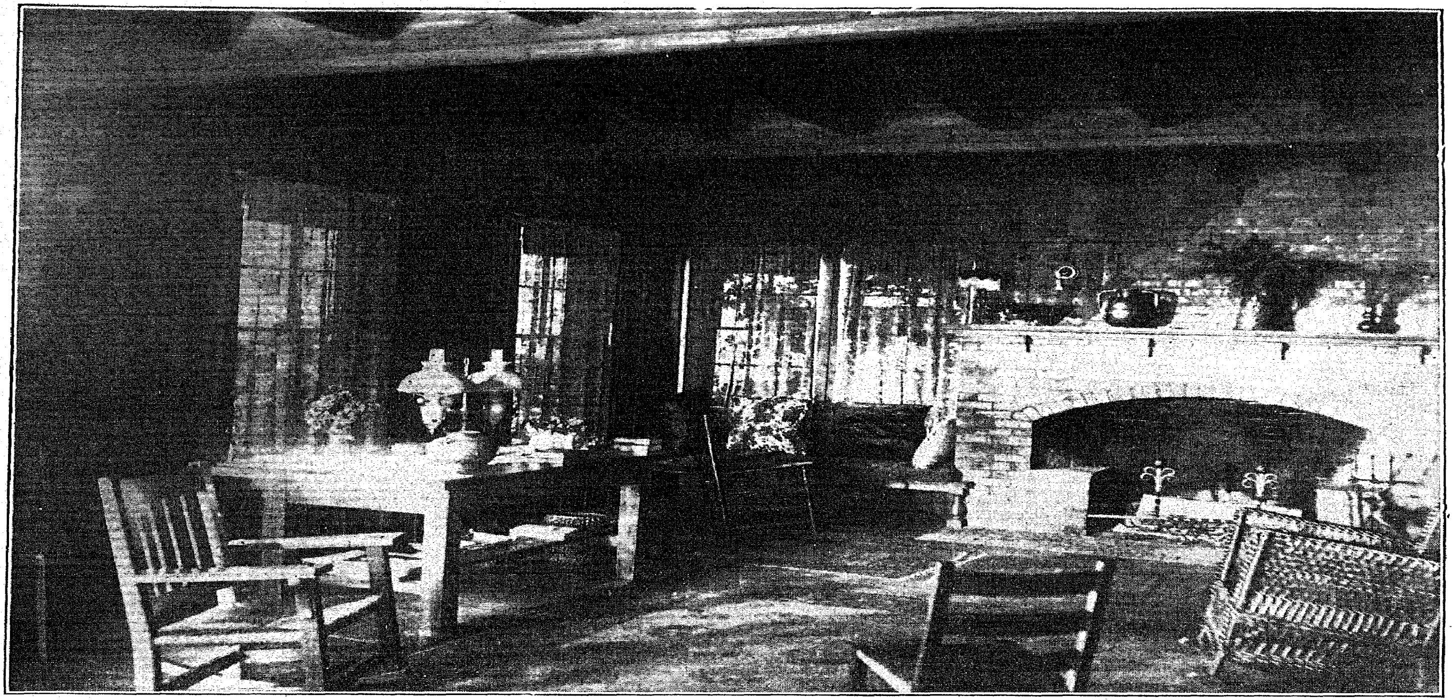


Fig. 123. Support of Corner.

Stairs. The stairs are built on frames called "stringers" or "carriages," which may be considered as a part of the floor framing. They consist of pieces of plank two or three inches thick and twelve or more inches wide, which are cut to form the steps of the stairs and which are then set up in place. There are usually three of these stringers under each flight of stairs, one at each side and a third in the center, and they are fastened at the bottom to the floor and at the top to the joists which form the stair well. This subject will be taken up more fully under "Stair Building."

Unsupported Corners. An interesting place in a floor framing plan is where we have a corner without any support beneath it, as at the corner *a* in Fig. 123. This corner must be supported from the three points *b*, *c*, and *d*, and the figure shows how this is accomplished. A piece of timber *e* is placed across from *b* to *c*, and another piece starts from *d* and rests on the piece *b c*, projecting beyond it to the corner *a*. This furnishes a sufficiently strong support for the corner.



LIVING ROOM IN SUMMER COTTAGE FOR THE MISSES DUMMER, AT HARBOR POINT, MICH.
Pond & Pond, Architects.
Hemlock Woodwork, Walls Stained a Silver Gray, Ceilings Stained a Gray Brown,
Fireplace of Paving Brick.

CARPENTRY.

PART II.

THE ROOF.

In Part I we saw that the subject of framing could be considered under three distinct headings; the framing of the wall, the framing of the floor, and the framing of the roof. So far we have discussed only the framing for the wall and that for the floor, so we will now take up the framing for the roof.

The roof framing is one of the most difficult problems with which the carpenter has to deal, not because of the number of complicated details, for there are few of these involved, but on account of the many different bevels which must be cut in order to make the rafters frame into one another correctly.

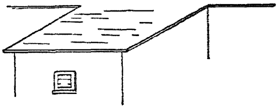


Fig 124 Lean-to Roof

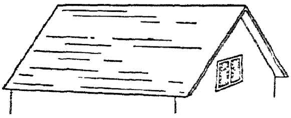


Fig 125 Pitch or Gable Roof.

Varieties of Roofs. There are many varieties of roofs, ranging all the way from the simple pitch roof to the most complicated combination of hips and valleys; but they are all developments of a few simple forms.

The *lean-to* roof is the simplest of all and is usually employed for small sheds, piazzas, porches, ells, and in many other situations. It is shown in Fig. 124. Its characteristic is that it has but one slope, which renders it unsightly and unfit for use on any important structure.

The *pitch*, or *gable*, roof is very common, and is also quite simple in form. It has two slopes, meeting at the center, or "ridge," and forming a "gable" at each end of the building. This form of roof is shown in Fig. 125. It is popular on account of the ease with which it can be constructed. It may be used in combination with roofs of other kinds.

The *gambrel* roof is somewhat like the gable roof, and is probably a development of it; but the gable is not triangular in shape, as is shown in Fig. 126. Gambrel roofs may be seen on many old houses, built in Colonial days, and they have lately come again into use.

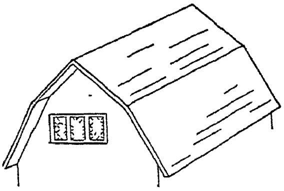


Fig 126 Gambrel Roof

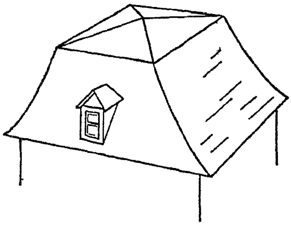


Fig 127 Mansard Roof.

The *mansard* roof, called by the name of the architect who introduced it, is like the gable roof except that it slopes very steeply from *each* wall toward the center, instead of from two opposite walls only, and it has a nearly flat "deck" on top. It bears a close relation to the so-called *hip* roof. It is shown in Fig. 127.

The *hip* roof mentioned above also slopes from all four walls toward the center, but not so steeply as does the mansard roof.

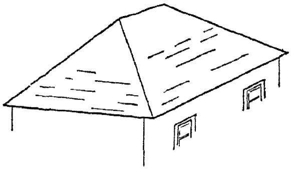


Fig. 128 Hip Roof

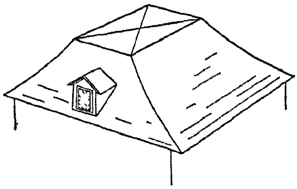


Fig 129. Hip Roof with Deck.

It is usually brought to a point or a ridge at the top, as in Fig. 128, but sometimes it is finished with a small flat deck, as in Fig. 129.

In Fig. 130 is shown a very simple form of what is known as the *hip-and-valley* roof. It is a combination of two simple pitch roofs which intersect each other at right angles. In the figure both ridges are shown at the same height, but they are not always built in this way. Either ridge may rise above the other, and the two roofs may have the same pitch, or different pitches.

If the ridge of the secondary roof rises above the ridge of the main roof, the end which projects above the main ridge is usually finished with a small gable, as shown in Fig. 131. This arrangement does not make a pleasing appearance, however, and should be avoided if possible.

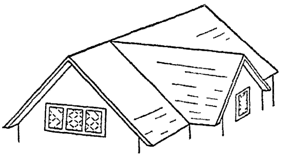


Fig. 130. Hip and Valley Roof.

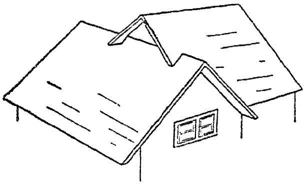


Fig 131. Hip and Valley Roof.

The Rafters. In all roofs the pieces which make up the main body of the frame are the rafters. They are for the roof what the joists are for the floor and what the studs are for the wall. They are inclined members, spaced from sixteen to twenty inches apart on centers, which rest at the bottom on the plate, and are fastened at the top in various ways according to the form of the roof. The plate, therefore, forms the connecting link between the wall and the roof, and is really a part of both. Rafters are sometimes made as small as two by six, but this is allowable only in the very lightest work. The size of rafters for common dwelling houses is usually two by eight. In some cases it may be found necessary to use rafters as large as two by ten for heavy work.

The connection of the rafters to the wall is the same in all the types of roofs described. They are not framed into the plate, but are simply spiked to it. Usually they extend out beyond the wall so as to form the eaves, as shown in Fig. 132, and they are then cut over the plate and allowed to continue beyond. Sometimes

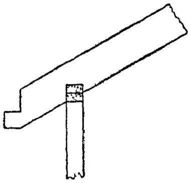


Fig 132. Rafters Extended over Plate.

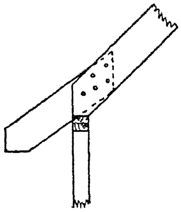


Fig. 133 Eaves Formed with Separate Piece.

the rafter itself is not extended beyond the plate, but is cut off at that point, and a separate piece is nailed against it to form the eaves, as shown in Fig. 133. This piece does not always continue in the same line with the rafter, but may make an angle with it, as shown in the figure, so as to give a break in the roof line.

There are four different kinds of rafters used in framing roofs, all of which may sometimes be found in a single roof, if it is of complicated design, while ordinary roofs may be framed with only the more simple forms. In Fig. 134 is shown the framing plan of a roof in which all four kinds of rafters are to be found. *a a a* are *common* rafters which extend clear up from the plate to the ridge and which are not connected with any of the other rafters. *b b b* are *jack* rafters which are shorter than the common rafters and which do not extend from the plate to the ridge, but are connected at one end to a *hip* or *valley* rafter. *c c* are the valley rafters, which are needed at every corner between the main building and an ell or other projection, while the *hip* rafters are found at every outside corner. At the points where the valley rafters are situated there are troughs or valleys formed by the roof surfaces—as these pitch downwards on both sides toward the valley rafter—while at the outside corners, where the hip rafters are found, the roof surfaces pitch upward on each side to the hip rafter. This may be seen by looking at any hip and valley roof as actually constructed.

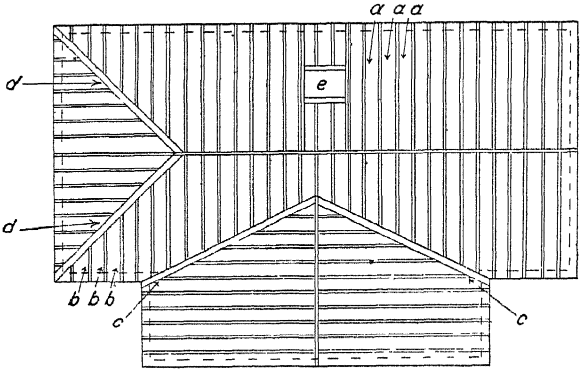
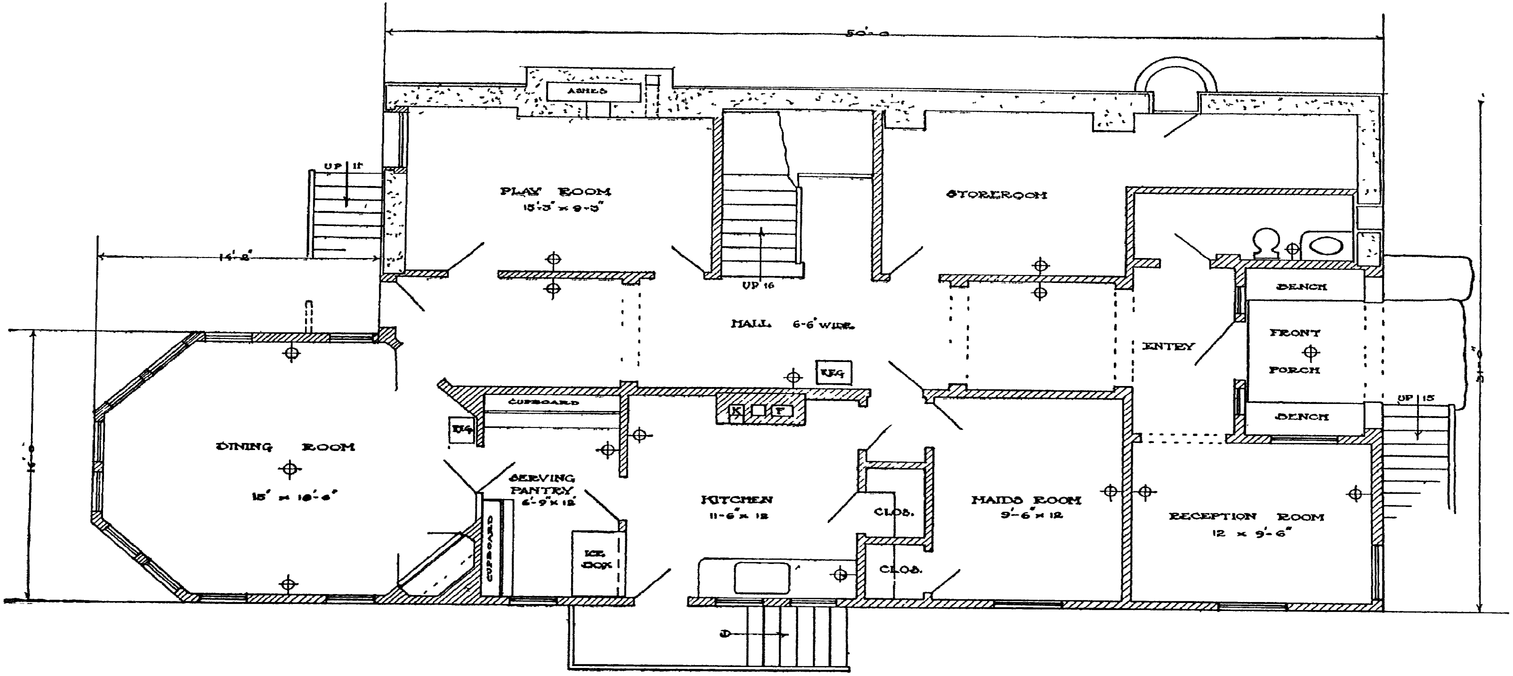


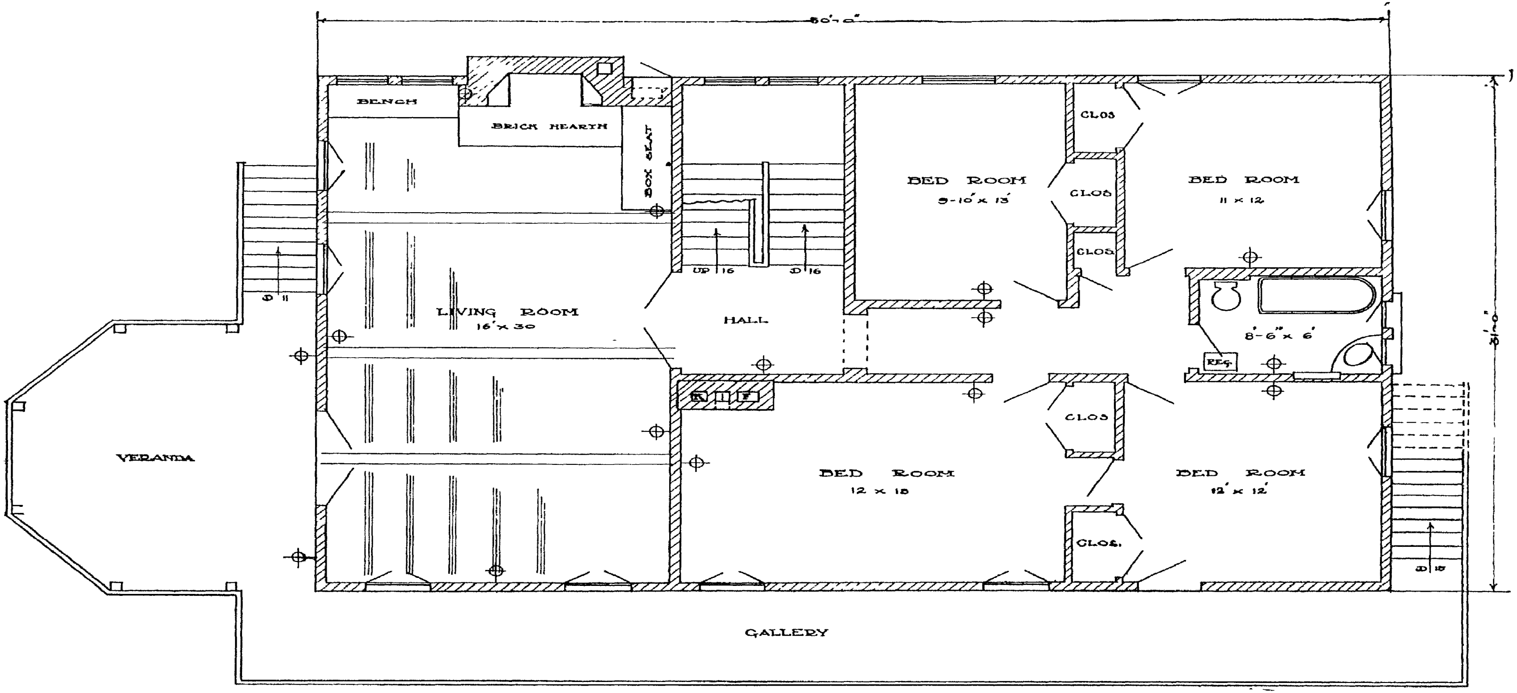
Fig. 134. Framing Plan of Roof.



GROUND FLOOR PLAN

SUMMER COTTAGE FOR THE MISSES DUMMER, AT HARBOR POINT, MICH. POND & POND, ARCHITECTS CHICAGO, ILL.

Built in 1903. Cost, $7,300. For Exterior, see Plate Opposite Foreword in this Volume; for Living Room, see Page 86.



FIRST FLOOR PLAN

SUMMER COTTAGE FOR THE MISSES DUMMER AT HARBOR POINT, MICH. POND & POND, ARCHITECTS

Ground-Floor Plan Shown on Opposite Page

In pitch or gable roofs there are no hip rafters, but there may be valley rafters and jack rafters, while common rafters are to be found in all roofs.

The Ridge. In the lean-to roof the rafters rest at the top against the wall of the building of which the ell, or porch, is a part; and the framing of the roof consists simply in setting them up and securing them in place with spikes or nails. The pitch roof, however, is formed on the principle that two pieces which are inclined against each other will hold each other up, and so the rafters must rest against each other at the top in pairs, as shown in Fig. 135. It is customary to insert between the rafters, at the top, a piece of board about one inch in thickness and deep enough to receive the whole depth of the rafter, as shown at *a* in Fig. 136. This piece of board is called the *ridge* or the *ridge pole* and extends the whole length of the roof. It serves to keep the rafters from falling sideways, and keeps the roof frame in place until the roof boarding is on. It is sometimes extended above the rafters, and forms a center for some form of metal finish for the ridge, as shown in Fig. 137.

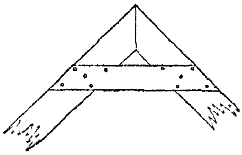


Fig 135 Top of Rafters

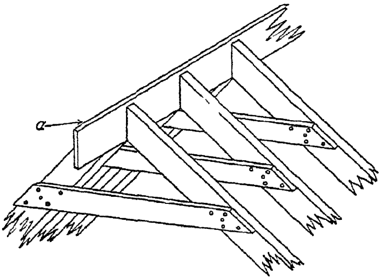


Fig 136 Ridge Pole Between Tops of Rafters

Interior Supports. In small roofs which have to cover only narrow buildings and in which the length of the rafters is small, there is no necessity for any interior support. When the rafters have been cut to the correct length, set up against the ridge, and secured in place, the framing is complete. In roofs of large span, however, the rafters would sag in the middle if they were not strengthened in some way, so it is customary to put a vertical support under them. This support may be formed by placing a piece of studding under each rafter, somewhere between the plate an the ridge, and if this is done very much lighter rafters can be use than would otherwise be considered safe. It is claimed by som that it is cheaper to do this than to use the heavy rafters. A mor common way of supporting the long rafters is to use fewer uprigh pieces and to place a horizontal piece *a* on top of them, runnin the whole length of the building and supporting each rafter This is shown in Fig. 138. An upright piece *b* should be place under every sixth or seventh rafter in order to give the necessar stiffness to the whole construction. For the uprights, pieces o ordinary studding, two by four inches or two by three inches i size, may be used. When there is to be a finished attic in th

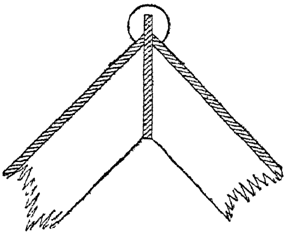


Fig. 137 Cross Section at Ridge Pole.

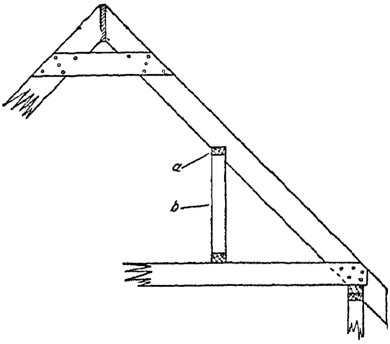


Fig. 138. Support for Long Rafters.

building these upright studs may be made to form the side walls of the attic rooms, and must then be spaced sixteen inches, or thereabouts, on centers. In this case a piece of studding could be placed under each rafter. Such walls are called *dwarf walls*.

Another form of interior support is the *collar beam* or *tie beam*. This is a piece of timber which extends between the rafters on opposite sides of the roof and ties them together, as shown at *a* in Fig. 139. It may be a piece of board about one inch thick and eight or ten inches wide, which is nailed onto the side of the rafter at each end. It is placed as near the center of the rafter as may be practicable, and in the case where a finished attic is required it forms the support for the ceiling. For this reason it must be at a considerable height from the attic floor, and cannot always be placed very near the center of the rafter. The important point is to see that it is well nailed at each end.

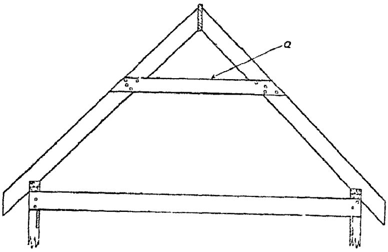


Fig 139. Tie Beam Support for Rafters.

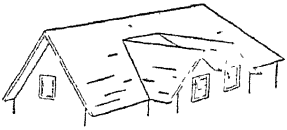


Fig. 140 Pitch Roof with Double Gable.

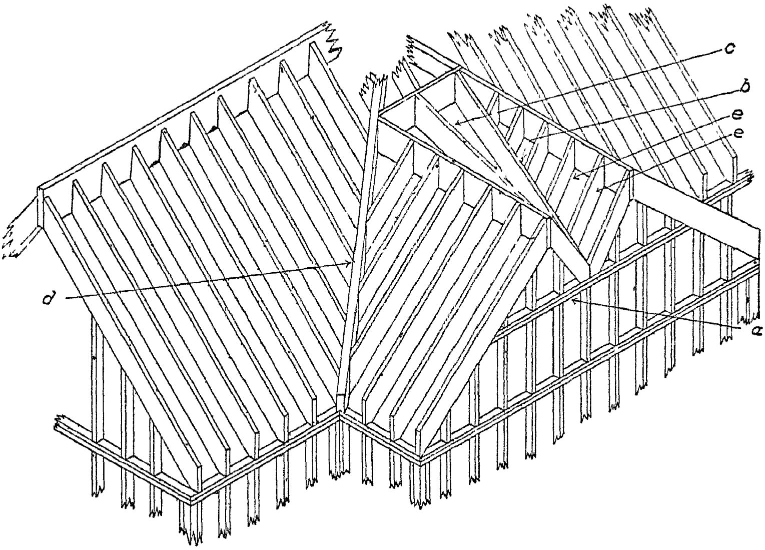


Fig. 141. Framing for Double Gable.

A very interesting form of gable roof is that in which there is a double gable with a valley between, which forms the roof of the ell, the main roof being a simple pitch roof. This is shown in Fig. 140. Fig. 141 shows how such a roof may be framed. The piece *a* is placed in the wall and supported by the studding and serves as a plate to receive the ends of the pieces *b*, which are valey rafters. These, together with the piece *c*, form the framing or the shallow valley between the two gables. The valley rafters n the outside, marked *d* in the figure, are similar to those used in the case of a single gable. The pieces *e e* are jack rafters and are very short. This form of roof is not common, but in some places it gives a good effect.

Framing of Gambrel Roof. A gambrel roof is framed in very much the same way as is a pitch or a hip roof. The slope of the roof, however, is broken at a point about midway between the plate and the ridge. The part of the roof above this break makes an angle with the horizontal plane of less than forty-five degrees, usually, while the portion below the break make an angle with the horizontal plane greater than forty-five degrees. This is shown in Fig. 126.

The lower slope may almost be considered a part of the wall, and at the point where the slope changes there is a secondary plate from which the upper slope starts, as shown at *a* in Fig. 142. The secondary plate may be utilized as a support for the ends of the ceiling joists *b*, which should also be securely spiked to the rafters, as shown in the figure. The rafters *c*, forming the upper slope, must be cut over the plate *a*, and firmly spiked to it, while at the top they rest against a ridge board *d*. The rafters *e*, forming the lower slope, are cut out at the top so as to form a seat for the plate *a*, and must be very securely fastened at the bottom to the main wall plate *f*. It is an excellent plan to have the floor joists *g* spiked to the lower rafters, so as to act like tie beams across the building and to counteract the outward thrust of the rafters. Sometimes these floor joists are dropped below the wall plate *f*, and are supported on a ledger-board notched into the wall studding *i*. This construction is not so good as that shown in the figure, because the joist is not so effective as a tie across the building. If it is employed, the floor joists must be securely nailed to the wall studding *i*, and they must not in any case be dropped more than two or three feet below the plate. The plate must always be firmly nailed to each stud to prevent it from being forced outward as it receives the thrust from the rafters *e*.

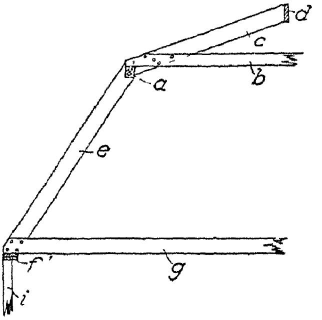


Fig. 142 Framing of Gambrel Roof.

A good rule for determining the point at which to place the secondary plate *a*, and for determining the general shape of the roof, is illustrated in Fig. 143. Let the points *a* and *b* represent the main plates on each side of the building. Draw a line *a b* between them and bisect this line at *c*. With *c* as a center and *c a* as a radius describe the semicircle *a d e f b*. At any distance *g* above *a b* draw a line *d f* parallel to *a b*, cutting the semicircle at the points *d* and *f*. Also bisect the arc at *e*. Then by joining the points *a d e f* and *b* by straight lines as shown, we will have the outline of a gambrel roof. The proportions of the roof may be varied by varying the distance *g*.

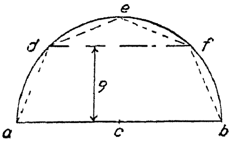


Fig. 143. Laying out Shape of Roof.

Gambrel roofs are not very strong unless they are stiffened by cross partitions in the attic stories, and these should be provided whenever it is possible. No gambrel roof, unless it is well braced, should be used on a building which is exposed to high winds, or which is likely to receive a heavy weight of snow.

Framing of Mansard Roof. A mansard roof is framed in very much the same way as is a gambrel roof, as may be seen in Fig. 144. Resting on the main wall plate *a* we have a piece *b* which is inclined slightly inward, and which supports at its upper end a secondary plate *c*. On the plate *c* rests the outer end of the deck rafter *d* which is nearly horizontal. The piece *b* is a piece of studding, two by four inches to four by six inches in size, depending upon the size of the roof. It supports the whole weight from the rafters, carrying it to the main wall plate and thence into the walls of the building. This member should always be straight, and the curved shape which is usual on mansard roofs is obtained by the use of the furring piece *e*. This piece is nailed to the upright member *b* at the top, and at the bottom it is secured to the *lookout f* which also forms a support for the projecting cornice. The floor joist *g* is supported on a ledger-board

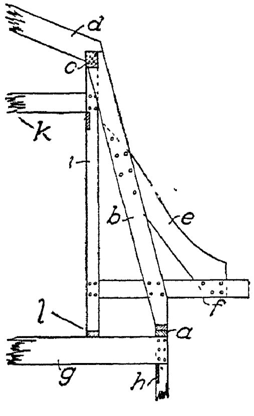


Fig. 144. Framing of Mansard Roof

h, or it may rest directly on the plate *a*. The piece of studding *i* is merely a furring stud to form the wall of the attic room. It may be omitted entirely if desired, or if the attics are to be unfinished. The ceiling joist *k* may be supported on a ledger-board as shown, or may be simply spiked to the studding *i* or to the upright *b*. The studding *i* may rest directly on the floor joists *g* with a sole piece *l* at the bottom, as shown. The plate *c* should be of a good size, at least four by six inches, and should not be placed more than two or three feet above the ceiling joists *k*. The ceiling joists act as ties across the building and prevent the plates *c* from spreading apart, as they receive the thrust from the rafters *d*. For this reason it is better to have the ceiling joist *k* fastened to the upright *b* rather than to the furring stud *i*.

Dormer Windows. In Figs. 145 and 146 are shown what are known as *dormer* windows, this name being applied to all windows in the roofs of buildings, whatever may be their size or shape. The figures show two different kinds of dormers which are in general use, the one shown in Fig. 145 resting entirely on the roof, while the one shown in Fig. 146 is merely a continuation of the wall of the building above the line of the eaves. The second type is often seen on low buildings, only one story in height, while the other kind is employed on larger structures.

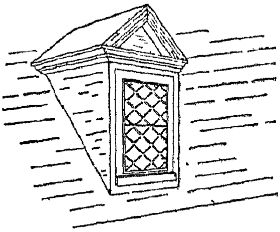


Fig. 145. Dormer Window.

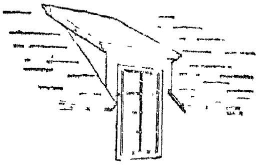


Fig. 146. Dormer Window.

In order to construct a dormer window an opening must be made in the roof surface, and the window must be built up over the opening. Headers are framed in between two of the rafters as shown at *a* and *b* in Fig. 147, and thus a rectangular opening is formed in the roof frame. The rafters *c* and *d*, which form the sides of the opening, are called *trimmers* and should be much stronger than the common rafters. Usually the trimmers are made by doubling the ordinary rafters. The headers receive the ends of the rafters which are cut by the opening, and must be large enough to carry the weight which comes from them beside supporting the walls of the dormer. Timbers four by eight inches to six by ten inches, according to the size of the dormer, are usually large enough for the headers and often smaller timbers may be safely used.

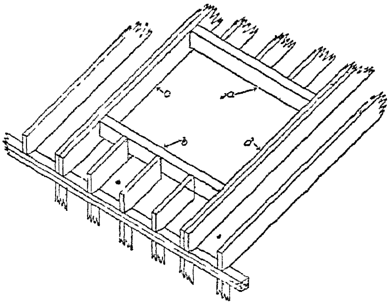


Fig. 147. Headers for Dormer Windows.

The headers are shown in section at *a* and *b* in Fig. 148, and it will be noticed that they are not put in in exactly the same way. The piece at the top *a* is so placed that its longer dimension is at right angles to the plane of the roof, while the piece at the bottom *b* has its longer dimension vertical. In the case shown in Fig. 146, where the front wall of the dormer is merely an extension of the main wall of the building, there is no need of the lower header *b*, the main wall plate taking its place and supporting the studding for the front wall of the dormer, as shown at the right hand side of Fig. 148.

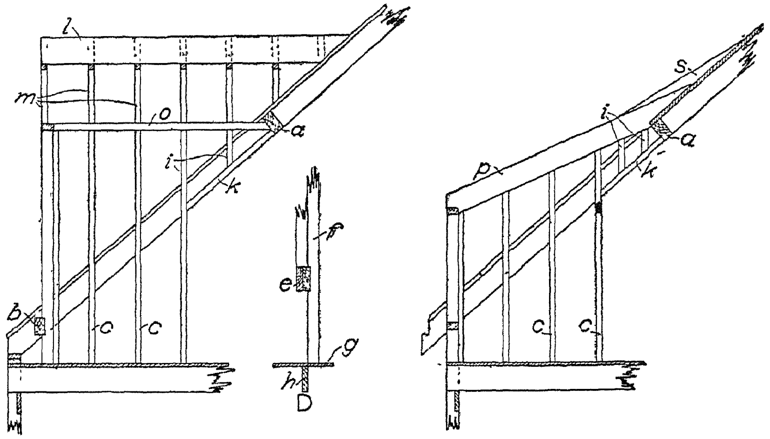


Fig. 148 Longitudinal Sections Through Dormer Windows.

Fig. 148 shows sections taken through two dormers of the types mentioned above, parallel to the direction of the main rafters and at right angles to the main wall plate of the building. At the left is a section taken through the type of dormer shown in Fig. 145, while at the right a section of the other type is shown. The studs *c c*, which form the side walls of the dormer, are notched over the trimmer rafters and roof boarding about one inch, and allowed to continue downward to the attic floor. This is shown at *D*. At *e* is a section of the trimmer rafter, *f* is the wall stud, *g* is the attic floor boarding, and *h* is a section of one of the attic floor joists. The studs *c* are in line with the studs forming the side walls of the attic room, so the studs *i* cannot be carried down to the attic floor. They are stopped, at the bottom, against a two by three-inch strip *k* which is nailed to the side of the trimmer rafter. At *l* is the ridge board, and *m m m* are the short rafters which form the pitch roof of the dormer. They may be very light, as they are short and carry little weight. They rest, at the foot, on a plate *o*, and at the top bear against the ridge board *l*. In the dormer shown on the right of the figure the rafters *p* are in planes parallel to the main rafters, and a furring piece *s* may be nailed to each of them so as to give the dormer roof any desired curve.

Beside the openings in the roof frame for dormer windows there must be other openings for chimneys and skylights. These are formed in the same way as explained for the dormer openings, with headers and trimmer rafters. A plan of such an opening is shown at *e* in the roof framing plan in Fig. 134.

RAFTER BEVELS.

At the points where the rafters intersect each other the ends must be cut on a bevel so that they will fit against one another accurately. The cutting of these bevels is the most difficult part of the roof framing. There is a different kind of bevel for each of the four kinds of rafters, so they will be considered separately.

Common Rafters. The common rafters are the most simple of all, and the bevels for them are easily cut when the pitch of the roof in which they are to be employed is known. Fig. 149 shows a plan and elevation of one common rafter *c*, with the ridge *a* at one end and the plate *b* at the other. It will be seen that the cuts may be made square across the piece since it is perpendicular to the plate *b* and to the ridge board *a*. There are two cuts to be made; one at the top, where the rafter comes against the ridge board a, known as the *plumb cut;* one at the foot, where the rafter rests on the plate b, known as the *foot cut.*

The upper edges of the rafters in any roof surface must all lie in the same plane in order that the surface may be smooth and even throughout. It is therefore necessary to work from the upper surfaces of the rafters in laying out the bevels, so that any unevenness which may result from a variation in the depth of the rafters will appear on the under side where it may be corrected by furring. We must start with the point d, which is the point in which the line of the upper edge of the rafter intersects the line of the outside face of the wall plate. Then $d e$, which is the distance from the outside face of the wall plate to the face of the ridge board, is the *run* of the rafter, and $e f$ is the *rise* of the rafter. The relation between this rise and run is called the *pitch* of the roof surface, and it determines the bevels, which may be easily marked off on the piece with the aid of the steel square.

To obtain the length of the rafter we must find the distance $d e$. The pitch of the roof surface will tell us the number of inches the rafter rises for each foot of run, and from this we may find the distance $e f$. The square root of the sum of the squares of the distances $d e$ and $e f$ will be the distance $d f$, which is the length of the rafter between cuts.

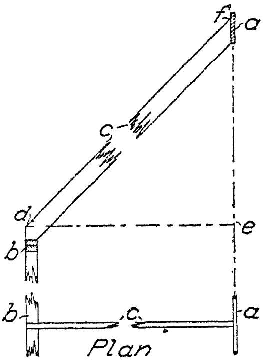


Fig 149 Plan and Elevation of Rafter.

Fig. 150 shows how the bevels for a common rafter can be cut very easily with the aid of the steel square. Suppose that we start with the rough piece $a b c e$ before it has been cut at all. Let us choose some point, as the point d, on the edge of the piece near one end, which we will take as the point in which the upper edge of the rafter is to intersect the line of the outside face of the wall plate. This point corresponds to the point d in Fig. 149. Let us suppose that the pitch of the roof surface is to be eight inches to the foot. Then we will apply the square to the piece, as shown in the figure by the full lines, with the eight-inch mark on the tongue at the point *d* and with the twelve-inch mark on the blade also on this same edge of the rafter. The line *d s k* along the tongue of the square is the line of the outside face of the wall plate, and if the rafter is not to project beyond the plate it should be cut on this line. If the rafter is to project beyond the plate so as to form eaves, we must measure off the required distance *k l* and draw the line *l m* parallel to *d s k*, cutting the piece on this line.

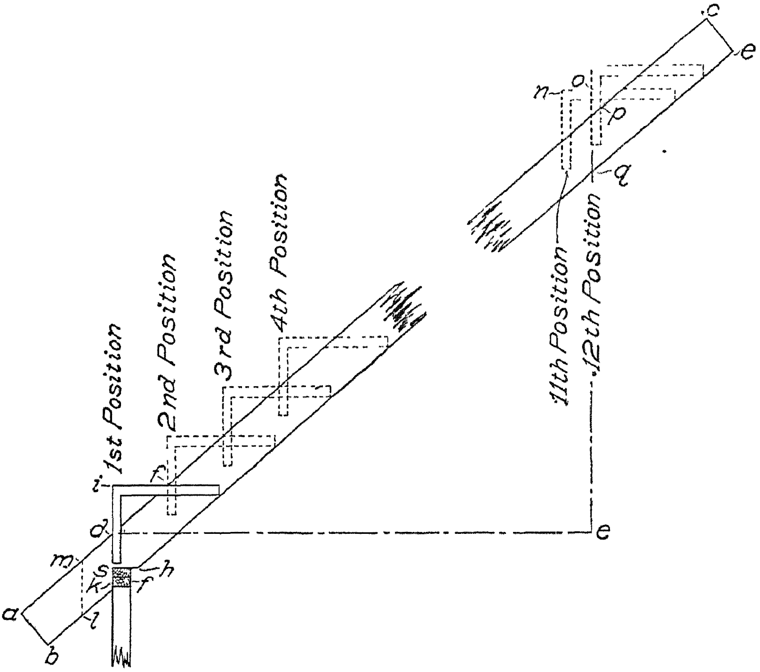


Fig 150 Cutting Bevel at Top of Rafter

Now to cut the bevel at the top of the rafter. Let us suppose that the run, the distance *d e* in Fig. 150, is ten feet and three inches. We will move the square along the edge of the rafter as indicated by the dotted lines eleven times, starting with the first position, shown by the full lines. When the square is in the eleventh position mark off three inches, *n* to *o*, on the blade, and slide the square along to the twelfth position. Then the line *p q* along the tongue of the square will be the line of the face of the ridge board, and the piece should be cut on this line.

A little study of the figure will suffice to reveal to anyone the reason for this method of procedure. Every time the square is moved into a new position it has advanced twelve inches or one foot along the run of the rafter, since the distance *i f* is twelve inches and is measured horizontally. After the square has been moved ten times it has advanced ten feet along the run of the rafter, and there is then left the three inches of the run which is accordingly measured off as explained above. This gives the position of the top bevel. It should be noticed that for a run of ten feet the square must be *moved along* ten times; for a run of eight feet, eight times; and so on. The run of the rafter may be easily obtained by subtracting one-half the thickness of the ridge board from one-half of the total span of the roof from outside to outside of wall plates. Sometimes the run is taken as exactly one-half the span of the roof, and then the rafter is *cut back* at the top by an amount equal to one-half the thickness of the ridge board. Another way to obtain the exact run of the rafter, from the outside face of the wall plate to the face of the ridge board, is to subtract the total thickness of the ridge board from the total span and divide the result by two.

The rafter must also be cut along the line *s h* at right angles to the line of the outside face of the plate, so as to rest on the plate, which is shown in the figure as *k s h f*. If it projects beyond the walls of the building to form the eaves, it must be cut on the line *k s* as well, leaving the notch *k s h* into which the plate fits. The distance *d s* may be varied to suit the conditions of each case, but must be made the same for all the rafters in any one roof surface.

The figure shows the rafter in the position which it would occupy in a building, the plate and a part of the wall studding being indicated.

Valley Rafters. We will next consider the valley rafters, and the bevels which must be cut for them. We have seen that in the case of the common rafters the bevels were determined by the pitch of the rafter, and since the same thing holds true for the valley rafters it is first of all necessary to be able to find the pitch of these members. By looking at the rafter *c*, in the plan in Fig. 134, it will be seen that it is a part of two different roof surfaces, and that it forms a connecting link between them. Its pitch, however, is different from the pitch of either of these roof surfaces.

To show how this pitch may be found let us consider a special case. Suppose that we have a roof B, with a pitch of twelve inches to the foot which is intersected by another smaller roof A with a pitch of eight inches to the foot, as shown in outline in Fig. 151. In Fig. 152, which is a plan of a part of the same roof, let *a b* be the ridge of the larger roof and let the dotted line *c d* be the ridge of the smaller roof. This ridge *c d* intersects the surface of the larger roof B at some point, as *y* in Figs. 151 and 152, the location of which on the plan is as yet unknown. Let the line *a e f g h i j b* represent the line of the outside face of the plate and let the dotted line just inside of this represent the inside face of the plate. The figure also shows an elevation of a common rafter in each roof and of the valley rafter, with the plate and a portion of the wall studding at *k*, and the rafters at *l*. The ridge boards are shown at *m*. The points *g′ f′* and *e′* show where the line of the upper surfaces of the rafters in each roof intersect the line of the outside face of the plate, and these points should all be at the same distance above the top of the plate, so that a line joining them would be horizontal. This may be accomplished when the rafters are cut by making the distance *g′ n* or *e′ o* the same for all of the rafters. It is evident also that the line of each ridge, *c d* or *a b*, must be horizontal, so that every point in either ridge is at the same level, or at the same distance above the top of the plate, as is every other point in the same ridge line. It may happen, in certain cases, that both ridge lines will be at the same elevation, but usually one ridge will be higher than the other, so that the roofs will intersect as shown in Fig. 151.

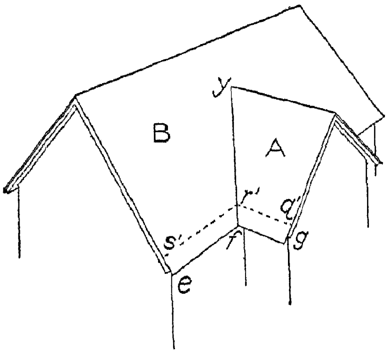


Fig. 151. Intersecting Roofs of Different Pitch

We must now find the position and the pitch of the line in which the two roof surfaces A and B intersect. The point *f* must be one point in this line, and in order to determine the position of the line we must find one other point in it. All lines in either roof surface which are parallel to the ridge lines, as q' r' and r' s', must be horizontal. Suppose that we draw the line q' r' in the roof surface A, making the distance g q or g' t just one foot. Then since this roof surface A has a pitch of eight inches to the foot, the point q' must be eight inches higher than the points g and f, or the distance t q' must be eight inches. This line q' r' is shown also in Fig. 151. It will be seen that it intersects the roof surface B at the point r' and since it is a horizontal line, this point r' must be eight inches above the point e, which is on a level with the points g and f.

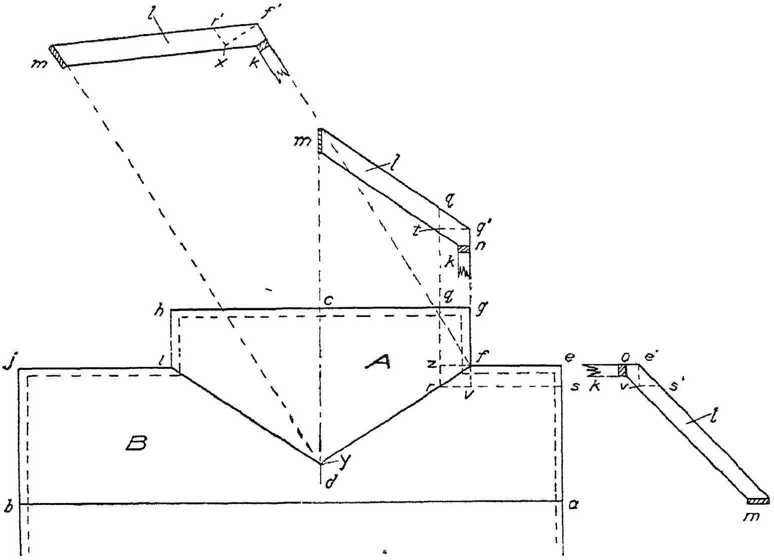


Fig 152. Plan of Intersecting Roofs

Now let us select the point s or s' in the roof surface B and let us suppose that it is also just eight inches above e f g. Since the pitch of the roof surface B is not eight inches to the foot like the surface A, but is twelve inches to the foot, the distance e s or e' v will not be twelve inches but will be $\frac{8}{12}$ of 12 inches, or eight inches. If then we draw the line s' r', in the roof surface B, making the distance e s or e' v eight inches, it will be at the same level as the line q' r' in the roof surface A and the point r' must lie in both lines, must be a point in the line of intersection of the two roof surfaces, and must be eight inches above the point f. The distance $r'\,x$, then, will be eight inches. A line drawn through the points f and r will give the position of the valley rafter on the plan, and it will be seen that it strikes the ridge $c\,d$ at the point y. Since $f\,y$ lies on the roof surface B, the point y must be the point in which the ridge $c\,d$ cuts the roof surface B, and the valley rafter $f\,y$ may be drawn at once in plan.

We have found that the distance $r\,z$ is eight inches and we started with the assumption that the distance $f\,z$ was twelve inches, so we see that the distance $f\,r$ or $f'\,x$ is equal to the square root of the sum of the squares of twelve inches and eight inches which is very nearly fourteen and one-half inches. The distance $r'\,x$, which is the rise of the valley for the run of fourteen and one-half inches we have found to be eight inches, so we know that the pitch of the valley is eight inches in fourteen and one-half inches, or six and five-eighths inches in twelve inches.

It will be noticed that since the distance $f'\,z$ is twelve inches and the distance $r\,z$ is, in this case, eight inches, the valley pitches horizontally toward the ridge $c\,y$ with a pitch of eight inches to the foot. In the same way, since $f\,v$ is eight inches, and $v\,r$ is twelve inches, it may be seen that the valley pitches horizontally toward the ridge $a\,b$ with a pitch of twelve inches in eight inches, or eighteen inches to the foot.

It will be noticed that the distance $f''\,r'$ on the valley rafter is the length on that rafter which corresponds to a run of $f'\,z$, or one foot, in the direction of the roof surface A. Also $(f'\,r')^2$ is equal to $(r'\,x)^2$ plus $(f''\,x)^2$. But $f''\,x$ is the same as $f\,r$ in the plan so that $(f'\,x)^2$ is equal to $(f'\,z)^2$ plus $(r\,z)^2$. Then $(f'\,x')^2$ must be equal to $(f'\,z)^2$ plus $(r\,z)^2$ plus $(r'\,x)^2$. In this particular case, we know that $f'\,z$ is twelve inches, $r\,z$ eight inches, and $r'\,x$ eight inches; so that the length on the valley rafter corresponding to a run of one foot toward the ridge $c\,y$ is equal to the square root of $12^2+8^2+8^2$. Multiplying this result by the number of feet and fractions of a foot in the half span of the roof A will give us the total length of the valley rafter. The half span of the roof A is shown on the plan as the distance $c\,g$; $f\,z$ may always be taken as twelve inches, and $r'\,x$ will always be given by the pitch of the roof surface A, being the rise of this surface per foot of run. We have only to find, then, the distance *r z*, which is the run of the roof surface B, giving the same rise as occurs in the roof A for a run of one foot. As we have seen *r z* is easily determined from the pitch of the roof surface B and we can find the length of the valley rafter.

Fig. 153 shows the plan of a roof in which there are a number of different kinds of valley rafters, and the same roof is shown in outline in Fig. 154. There is a main roof A, a small gable B, not so high as the main roof, and a larger gable C, the ridge of which is on the same level with the main ridge. The plan in Fig. 153 shows the method of framing the roof when a small gable intersects the main roof surface. One of the valley rafters *a b* is carried clear up to the main ridge and bears against it, while the other valley, *c d*, bears against *a b*. It will be seen that the lower part of the rafter *a b* from *b* to *d* lies in both the roof surfaces A and B, but that the portion from *d* to *a* lies entirely in the surface A. This plan shows all the different bevels that will have to be cut on valley rafters. At the top of rafter *a b*, where it meets the ridge *i h*, is a single bevel which is determined by the pitch or inclination of the rafter toward this ridge. At the top of the rafter *c d* is a single bevel which is determined by the angle between *c d* and *a b*. It will be noticed that this angle is just double the angle between *c d* and the ridge *d g*, so that it, too, is determined by the inclination of *c d* toward this ridge. At the top of the rafter *o e* there are two bevels; one determined by the pitch of the rafter

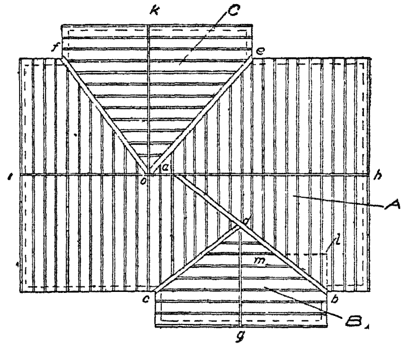


Fig 153 Plan of Roof with Different Valley Rafters.

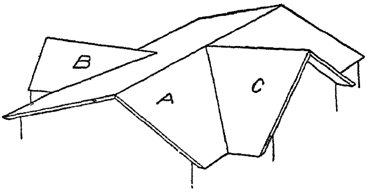


Fig. 154 Outline of Roof with Different Valley Rafters.

toward the ridge *o k*, and the other by the pitch of *o e* toward the ridge *o h*. At the top of the rafter *o f'* are two bevels similar to those at the top of *o e*.

We will now consider how bevels may be cut on the pieces with the aid of the steel square. The cut at the foot of the rafter is simple, and is made in the same way as for a common rafter, as shown in Fig. 150. The distance *d s* must be the same for every one of the rafters, whether they are valley rafters, common rafters, hip rafters, or jack rafters, and may be varied to suit the circumstances. The notch *k s h* fits over the plate and the point *s* is at the upper outside corner of the plate.

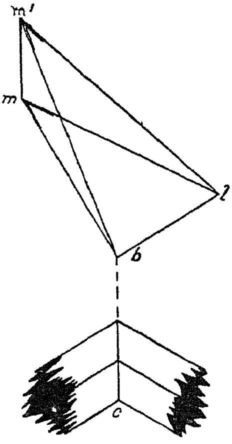
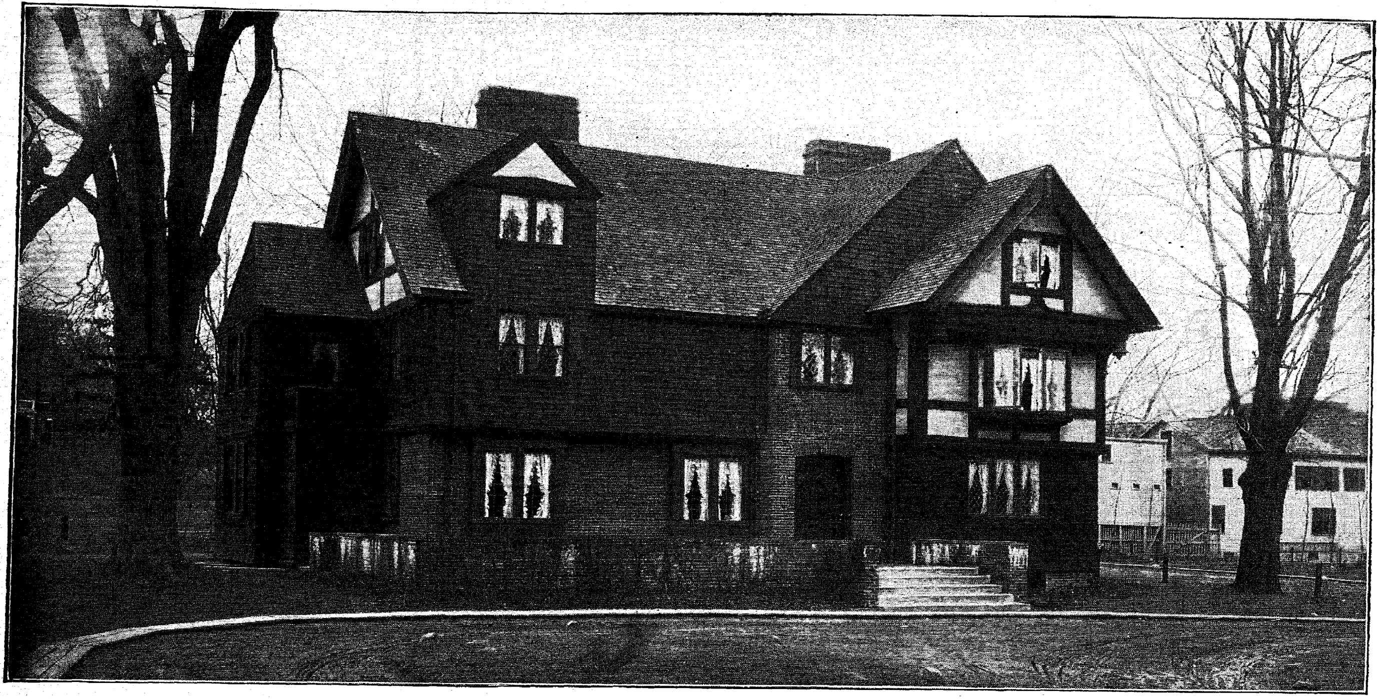


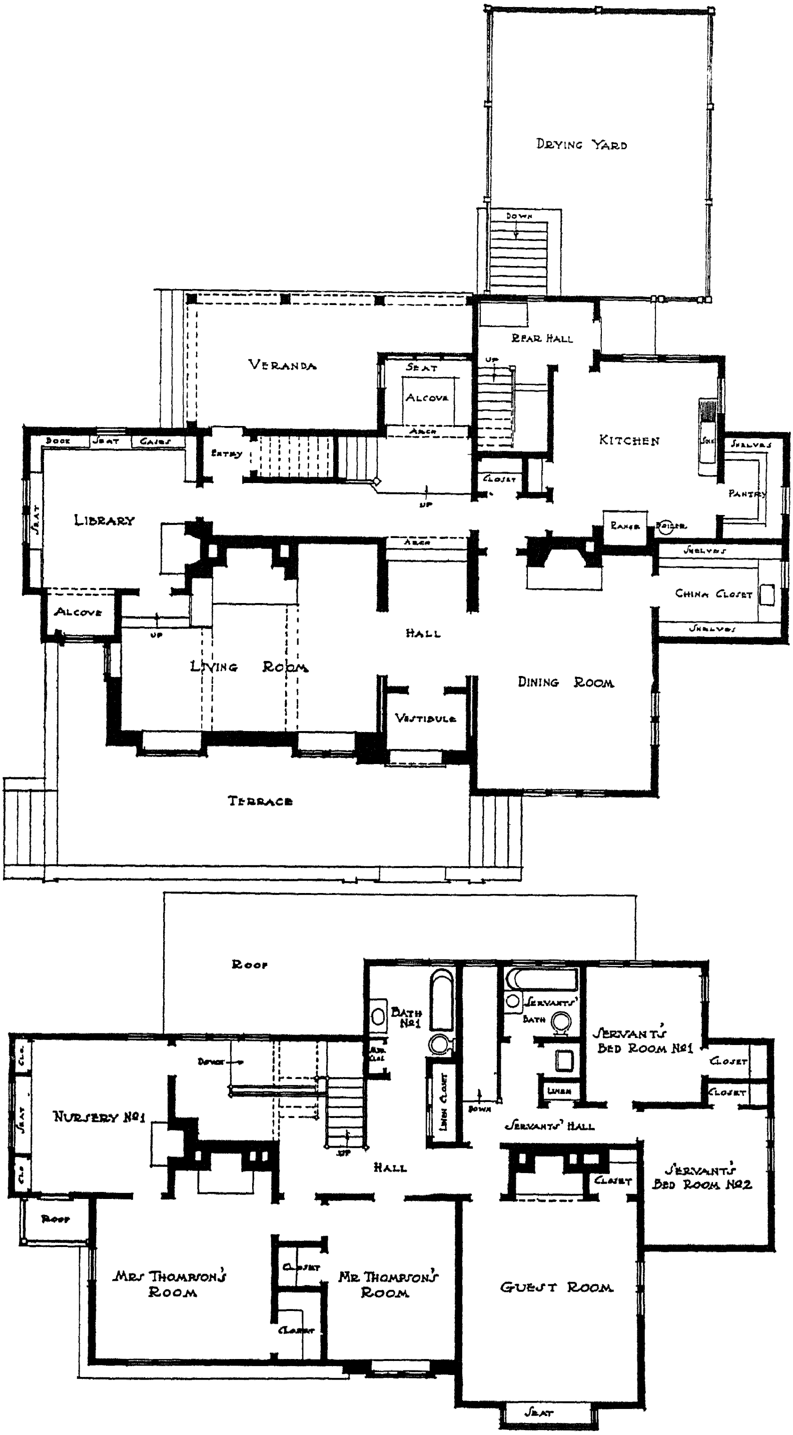
Fig. 155. Calculating Length of Valley Rafters

We have seen that the length of the valley rafter may be obtained directly from the half span of one of the roof surfaces in which it lies, and this is shown in Fig. 155, which gives in isometric drawing the lines *b l*, *l m*, and *b m* in Fig. 153. The distance *b l* may be taken as just one foot of the half span of the roof A; the distance *m m'* is the amount which the roof surface A rises in this run of one foot, and the distance *b m'* is the actual distance from *b* to *m* measured along the line of intersection of the two roof surfaces. The point *b* corresponds to the point *f'* in Fig. 152, and a portion of the plate is shown at *c*.

Referring to the plan in Fig. 153, we see that the line *l m* is parallel to the ridge *i h*, so that the angle *l m b* determines the bevel at the top of the rafter *a b* at *a*. In Fig. 155, *l m' b* is the actual bevel and *l m b* shows the bevel as it appears on the plan. It will be noticed that the angle *l m' b* is much more acute than the angle *l m b* on account of the rise of the valley. Note also that the angle *b l m'* is a right angle, so that the square of *b m'* is equal to the square of *b l* plus the square of *l m'*, and that the square of *l m'* is equal to the square of *l m* plus the square of *m m'*. Remembering that *b l* represents just one foot of the span of the roof A, that *m m'* is the rise of the roof surface A per



HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York
The Seven General Contract Estimates Ran from $18,715 down to $11,769. The House was Built at the Latter Figure, plus a Great Many Extras Added by the Owner; and to this Amount was Added $2,000 for Plumbing and Heating. It was Built in 1900. The House Faces about South.
For Interiors, See Pages 122, 138, and 155.



FIRST AND SECOND STORY PLANS OF HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.

Cram, Goodhue & Ferguson, Architects, Boston and New York.

foot of run, and that *l m* is the run of the roof surface B which will give this same rise, it will be seen that the length *b m'* may be easily obtained. By using the steel square we may avoid squaring all of these quantities.

In Fig. 156, let us suppose that we have a piece of timber from which we wish to cut the valley rafter. Suppose that we have selected the point *m'* as the starting point, corresponding to the point *f'* in Fig. 152, and that we have made the foot cut as shown, and as explained above for the common rafters. We now wish to get the length of the rafter so that we can make the plumb cut or *down bevel* at the top of the piece. If we place the square along the edge of the piece as shown by the light full lines with the distance *m' m* on the tongue and the distance *l m* on the blade, we can at once lay off the distance *l m'* by marking the points *m'* and *l* on the wood.

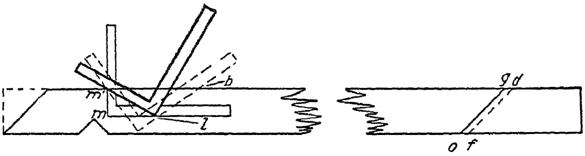


Fig 156 Framing Valley Rafter

Now let us place the square in the position shown by the heavier full lines, so that the heel will come at the point *l* and so that the edge of the tongue will pass through the point *m'*. We have now the distance *l m'* laid off along the tongue of the square. Keeping the point *m'* always in the same position, so that we always have the distance *l m'* on the tongue of the square, let us revolve the square about the point *m'*, as shown by the dotted lines, until the twelve-inch mark on the blade coincides with the edge of the rafter at *b*. We then have the distance *b l*, or one foot, on the blade, *l m'* on the tongue, and *b m'* along the edge of the rafter. The distance *b m'* may be laid off as many times as there are feet and fractions of a foot in the half span of the roof, giving the point *d*; then *d f* is the plumb cut at the top of the rafter parallel to the foot cut, and *g o* shows where we must cut back to allow for the thickness of the ridge board.

Fig. 157 shows how we may cut the bevel shown at *a* in the roof plan in Fig. 153. The actual bevel at this point is shown in Fig. 155 by the angle *b m' l*. Let *b m l* be the center line of the top edge of the rafter. The point *l* has been found as explained above and corresponds to the point *d* in Fig. 156. It is the point in which the center line of the valley intersects the center line of the ridge. First place the square as shown by the dotted lines with the distances on the blade and tongue as shown. A mark may be made at *m'* which gives the distance *m' l* and the square may be applied again, with this distance *m' l* on the blade and *b m'*, equal to just twelve inches, on the tongue. The blade then gives the bevel. The rafter must be cut back, to allow for half the thickness of the ridge.

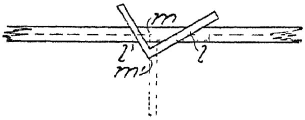


Fig. 157 Cutting Bevel

For the cut at the point *d* in Fig. 153 where the valley *c d* comes against the valley *a b*, we apply the square in the same way, as shown in Fig. 158, using different values for the distances *l m* and *m m'*. The angle *b l m'* must then be doubled, as shown, and the line *o p* gives the cut.

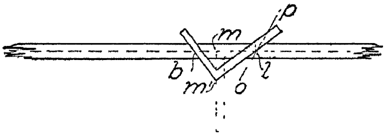


Fig. 158 Cutting Valley Rafters.

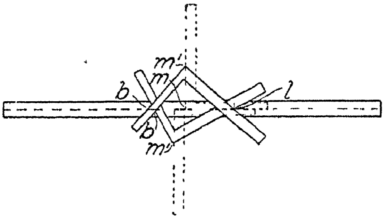


Fig. 159 Cutting Double Bevel.

The double bevel at the point *o* in Fig. 153 is obtained, as shown in Fig. 159, by applying the square on both sides of the center line of the top edge of the rafter, using different values for *m m'* and *m l*, according to the pitch of the roof surfaces. This gives the two cuts along the blade of the square, in its two final positions, shown by the full lines.

It will be noticed that in making all of these cuts for valley rafters, there are two distances, *m m'* and *m l*, which are used as starting points, and by which the position of the square on the piece is determined. *m m'*, as has already been explained, is the rise of one of the two intersecting roof surfaces, corresponding to a run of one foot, while *m l* is the run of the other roof surface which corresponds to a rise of *m m'* in this roof. These distances are easily determined from the pitch of the two intersecting roof surfaces, which is always known, and from them any bevel on any valley rafter can be found, as well as the run, or *seat*, of the valley rafter, its rise, its length, etc.

Hip Rafters. Fig. 160 shows the plan of a roof in which there are some hip rafters. At one end we have a square hip A, and at the opposite end we have a skew hip B. The hip rafters are shown at *a b*, *a c*, *d e*, and *d f*. They rest on the plate at the foot, and bear against the ridge board *a d* at the top. At *g h* is shown also a valley rafter. It will be seen that the hip rafter is exactly the same as the valley rafter. It has the same pitch, or inclination, toward the ridge *a d*. Its pitch must be the same since it lies in the same roof surface, and is parallel to the valley. This similarity between hip and valley rafters is characteristic, and the same methods of cutting bevels which were explained in connection with valley rafters are eqally applicable in the case of hip rafters. The pitch of the hip roofs A and B may be varied to suit the design, but usually the hip roofs have the same pitch as the main roof. The position of the hip rafter on the plan is determined from the pitch of the two roof surfaces of which it is a part in the same way as was explained for valley rafters. All lines in the roof surfaces A and B which are parallel to the plates *b c* and *e f* are horizontal, and have the same elevation throughout their length. There is but one bevel at the top of the hip rafter where

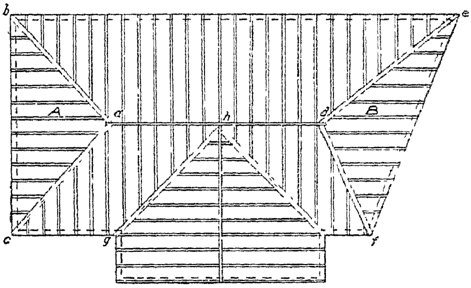


Fig. 160. Plan of Roof with Hip Rafters.

it bears against the ridge, and this is similar to that at the top of the valley. It is cut in the same way as the valley rafter.

Curved Hip Rafters. A form of hip rafter which is sometimes a source of considerable trouble is one which occurs in a curved roof, such as an *ogee* roof over a bay window, or a curved tower roof. The shape of the curve to which the top edges of the common rafters must be cut, is determined from the shape of the section of the curved roof surface, but the curve at the top of the hip rafter is entirely different, and must be determined in another way. The principle used in finding this curve is the same as was employed in the case of the valley rafter, namely, that any line drawn in the roof surface parallel to the wall plate must be horizontal, or that it must be at exactly the same elevation throughout its entire length.

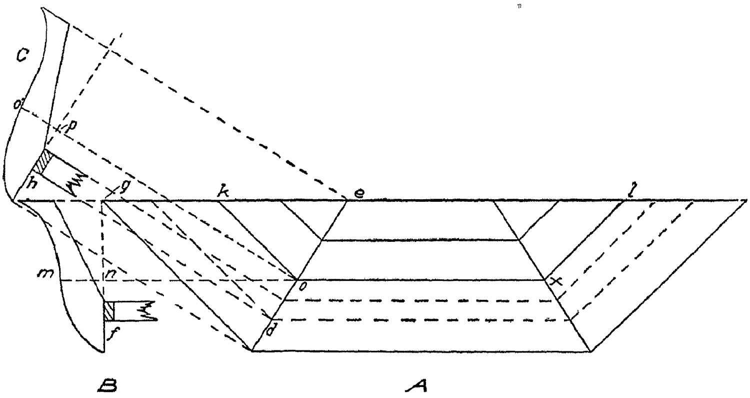


Fig. 161. Ogee Roof over Bay Window.

Fig. 161 shows how this principle may be applied. At A is shown a plan of an ogee roof over a bay window with a hip rafter, *d e* and common rafters. At B is shown an elevation of one of the common rafters cut to coincide with the curve of the roof surface. The shape of the curve may be varied to suit the fancy of the designer. At C is shown an elevation of the hip rafter *d e*, showing the curve to which it must be cut in order to fit into the roof.

To determine this curve we draw on the roof plan at A any number of lines, parallel to the wall plate. These must be horizontal, so that any point in either of the lines is at the same height above the top of the plate as is every other point in the same line. The lines *f g* and *h i* in the elevation, shown at B and C, represent the level of the top of the plate. By projection we find that the line *k o x l*, for example, is at a distance *m n* above the top of the plate at the point where it crosses the common rafter shown at B. Every other point in this line is at the same elevation, including the point *o*, in which it intersects the center line of the hip rafter *d e*. By projection we can locate the point *o′* in the elevation shown at C, making the distance *o′ p* equal to the distance *m n*.

In the same way we can obtain as many points in the curve of the hip rafter as we have lines drawn on the roof plan. The lines may be drawn as close together as we wish, and the number of points obtained may thus be increased indefinitely. When a sufficient number of points have been thus located, the curve can be drawn through them, and a pattern for the hip rafter is thus obtained. The shape of the curve for a valley rafter is found in the same way as explained for a hip rafter.

Jack Rafters. Fig. 162 shows the plan of a roof in which there are hip, valley, and jack rafters; *a b* and *b d* are hip rafters, *c e* is a valley rafter, and the rest of the framing is made up of common rafters and jack rafters. At *b f* and *e h* are shown the ridge boards. Of the jack rafters there are three different kinds; those like *i j*, which run from the valley rafter to the ridge board; those like *k l*, which run from the hip rafter to the plate; and those like *i t*, which run between the hip and valley rafters. These differ from each other only with respect to the bevels which have to be cut on them. The jack rafter *i j* has a simple plumb cut at the top, where it meets the ridge board, similar to that at the top of a common rafter; and at the bottom *i* where it meets the valley rafter, it has two cuts—a plumb cut and a cheek cut—which are similar to the cuts on a valley rafter where it comes against a ridge board, as explained above. The

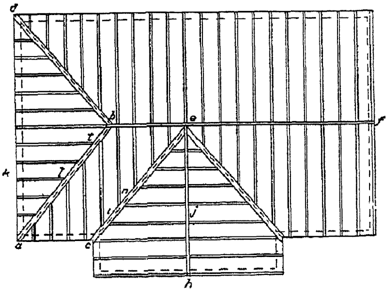


Fig. 162 Roof with Hip, Valley and Jack Rafters

rafter *k l* has a simple foot cut at the bottom, like that for a common rafter, while at the top it has two cuts like those at the foot of *i j*. The rafter *i t* has two cuts at each end, a plumb cut and a cheek cut, where it comes in contact with the hip and valley rafters. All of these bevels can be obtained by the same methods as were employed for finding the bevels on the valley rafters. Everything depends upon the pitch of the roof in which the rafters lie, and the angle between them and the valley or hip rafters. The length of a jack rafter is proportional to its distance from the ridge or plate to which it is parallel, the longest one being equal in length to a common rafter, and the lengths decreasing steadily from this point to the point where the valley meets the ridge, or where the hip meets the plate, as the case may be.

BACKING OF RAFTERS.

Hip Rafters. In Fig. 163 we have a plan, in outline, of a part of a roof with a hip *g d* in which the two surfaces A and B come together. Let us suppose that the pitch of the roof surface A is eight inches to the foot, and that of the surface B is twelve inches to the foot. Let the lines *f c d* and *d b e* represent the outside faces of the two wall plates, which come together at the corner, and let the dotted lines just inside of these represent the inside faces of the plates. Suppose that the distance *a b* is just twelve inches, and we have the point *a* just eight inches above the points *b*, *d* and *e*, since the pitch of the surface A is eight inches to the foot. As the pitch of the surface B is twelve inches to the foot, the distance *c a* must be eight inches, in order to give a rise of eight inches at the point *a*, and the distance *d b* must also be eight inches, and *c d* must be the same as *a b*, which is twelve inches.

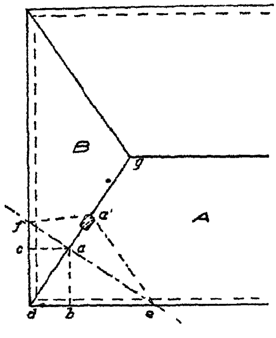


Fig 163 Part Plan of Hip Roof.

Now suppose that the line *f a e* be drawn through the point *a* perpendicular to the hip line *d g*, and let it represent a vertical plane which is passed down through the roof surfaces, perpendicular to the plan of the hip line, cutting the hip rafter and plates.

Fig. 164 shows the section of the roof surfaces cut out by this plane. We have the point *a*, eight inches above the points *f* and *e*, making the distance *a h* eight inches. The dotted lines show the roof surfaces, and *a e* and *a f* are the lines which are cut out of these surfaces by the vertical plane. The section *m n o p* shows, much exaggerated in size, the section of the hip rafter cut out by the vertical plane, and it will be noticed that the upper corners of this rafter *a m j* and *a n i* project out into the roof surfaces on each side. These projecting corners must be cut off, so that the section of the rafter will be *a i p o j* and this is called *backing* the rafter. At C is shown an isometric drawing of the rafter, lettered the same as in the section, so that it may be more easily understood just what the *backing* involves.

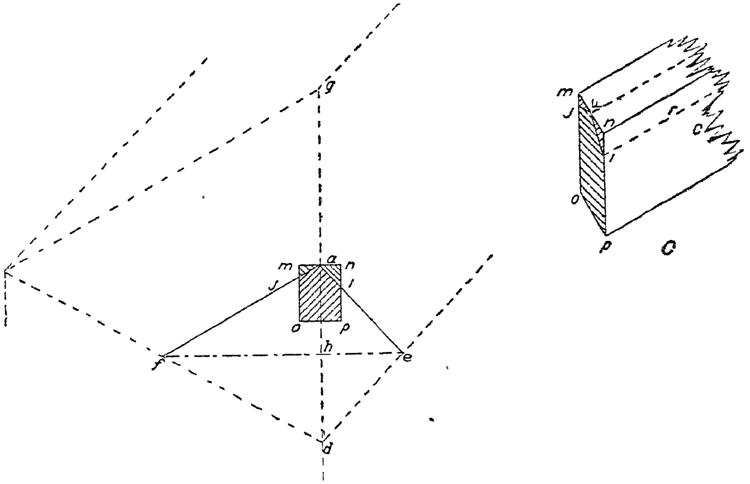


Fig 164 Section through Roof Surfaces

The question is "How do we know how much to cut off from the corners of the rafter in any particular case, and how can it be indicated on the piece of timber so that these cuts can be made?" This question will now be answered.

In making the foot cut on the rafter, we have to cut out just such a vertical section as is indicated in Fig. 164. We can find the point *a* on this section in the center of the top edge of the rafter and draw lines *a j* and *a i* directly on the section of the piece, and from the points *i* and *j* lines like *i r*, in the isometric view at *c*, can be drawn on the sides of the rafter, which will show the amount to be cut off from the corners. In order to do this, however, we must know the bevel of the lines *a e* and *a f*; that is, we must know the angles *n a i* and *m a j* for any particular case. In the case we are considering we know that the distance *a h*, Fig. 164, is eight inches, as explained above, and we need only to find the distances *h e* and *h f* in order to determine the two bevels. The distances *a e* and *a f* in the plan, Fig. 163, are the same as *h e* and *h f* in Fig. 164. Now let us find *a e*. The length of *a b* was assumed at the start to be twelve inches, and *d b* was found to be eight inches. On account of the similarity of triangles, $\frac{d\,b}{a\,b}$ is equal to $\frac{a\,b}{b\,e}$, so that *b e* is $\frac{12}{8}$ of *a b*, or eighteen inches. Then *a e* must be about twenty-one and one-half inches, and *h e* in Fig. 164, is the same. We now know both *h e* and *a h* in Fig. 164, and these two distances determine the bevel of the line *a e*. In the same way, the distance *h f* may be found and the bevel of the line *a f* may be determined. It may sometimes be found more convenient to draw the roof plan accurately to scale and then to scale the distances, instead of calculating them, but this amounts to the same thing in the end. The bevels of the lines *a f* and *a e* may also be found graphically as shown in Fig. 165. Suppose this plan to be drawn accurately to a fairly large scale. Starting with the point *a* on the hip line *d g*, we draw the line *c a f*, perpendicular to the hip line, and the lines *a b* and *a e* perpendicular to the wall lines *d e* and *d f*. From *b* we can draw the line *b a''* making the same angle with *a b* that the roof surface A makes with the horizontal plane. Then if *a a''* be drawn from *a* perpendicular to *a b* the distance *a a''* will be equal to the actual elevation of the point *a* above the point *b*. Thus distance can be laid off along the hip line, *d g* perpendicular to the line *f a e*, by swinging the point *a''* around

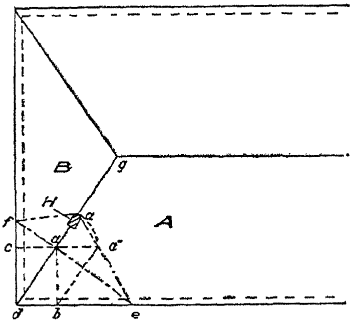


Fig. 165. Graphical Method of Finding Bevels.

to *a'*. Then the distance *a a'* is equal to the elevation of the point *a* above the point *b*, and above the points *e* and *f* also. The lines *a' e* and *a' f* make the same angle with the line *f a e* that the lines *a e* and *a f*, in Fig. 164, make with the horizontal, and we can get the bevels from these lines. At H is shown a small section taken vertically through the hip rafter, similar to the section of the rafter shown in Fig. 164.

Valley Rafters. In Fig. 166 we have a plan in outline of a part of a roof with a valley *a b* between the roof surfaces C and D and with ridges *b c* and *b d*. Let us assume the pitches of the roof surfaces to be, as before, eight inches to the foot for C and twelve inches to the foot for D. Assume *a e* to be twelve inches, and *e f* will be eight inches and the point *f* must be eight inches above the point *a*, as explained in the case of the hip rafter. Since we know *a e* and *e f* in Fig. 166 we can find *e i* from the similarity of the triangles, as in the case of the hip rafter, and then we can find both *a i* and *f i*. Knowing *a i*, and knowing the pitch of the roof surface C, we can find the elevation of the point *i* above the point *a*. Since we know that the point *f* is eight inches above the point *a* we can find the elevation of the point *i* above the point *f*, and this with the distance *f i* will give the bevel of the line *f i* in Fig. 167. In the same way the bevel of the line *f j* may be found. These bevels can be laid off on the vertical section of the valley rafter which is cut out when the foot cut is made, and the distances at which the tops of the jacks, E and F in Fig. 167, must be set above the top of the valley rafter *g* may be determined. In order that the lines *f i* and *f j* in Fig. 167 may come on the surface of the valley rafter section, they may be drawn

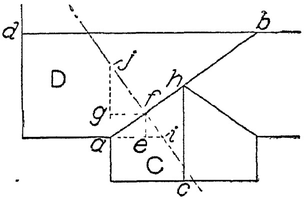


Fig 166 Roof with Valley and Ridges

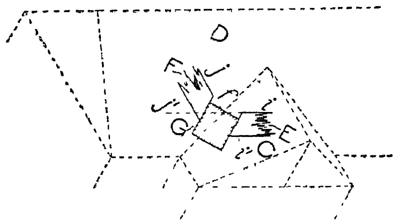


Fig. 167. Method of Finding Bevels.

sloping downward instead of upward, as shown at $f\,i'$ and $f\,j'$. The point f is always in the center of the top edge of the valley rafter.

Fig. 168 shows how the bevels for the valley rafter may be found graphically. Starting with the point f we can draw lines $o\,f\,p$, $a\,e\,i$, and $a\,g\,j$ perpendicular respectively to the valley line $a\,h$ and to the two outside wall lines. The lines $a\,i''$ and $a\,j''$ having been drawn corresponding to the pitches of the two roof surfaces, we have the distances $i\,i''$ and $j\,j''$ showing the elevation of the points i and j. These distances can now be swung around perpendicular to the line $o\,f\,p$, so as to give the points i' and j'. The distances $e\,f''$ and $g\,f''$, which should be the same, show the elevation of the point f, and this distance may be laid off perpendicular to $o\,f\,p$, as shown at $f\,f'$. Then the lines $f'\,i'$ and $f'\,j'$ correspond to the lines $f\,i$ and $f\,j$, in Fig. 167, and give the bevels which we need. At Q is shown a vertical section of the valley rafter and the jack rafters similar to Fig. 167.

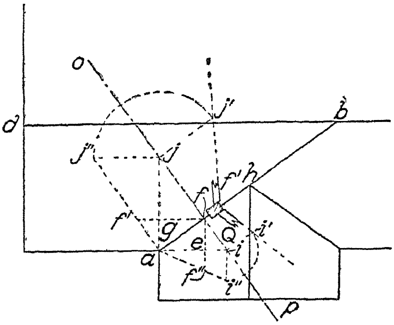


Fig. 168. Graphical Method of Finding Bevels.

ATTIC PARTITIONS.

It is often necessary to build partitions in the story directly beneath the roof, and such partitions must extend clear up to the under side of the rafters and connect with them in some way. This makes it necessary to cut the tops of the studs on a bevel to correspond with the pitch of the rafters, and the cutting of this bevel is not always an easy task. Fig. 169 shows the framing plan of the roof of a small simple building. $a\,b$ is the ridge. The plate extends around the outside from c to d to e to f, and back again to c; and $g\,h$, $i\,j$, $k\,l$ are the rafters. A partition is shown beneath the roof running diagonally across the building, making an angle with the direction of the rafters and an angle with the direction of the ridge. At $n\,o$ is shown another partition running parallel to the ridge, and at $p\,q$ still another, running parallel to the rafters. Now since all the rafters slope upwards from the plate to the ridge, it is evident that the tops of all the studs must be cut on a bevel if they are to fit closely against the undersides of the rafters. This is illustrated in Fig. 170, where the stud A must fit against the rafter B.

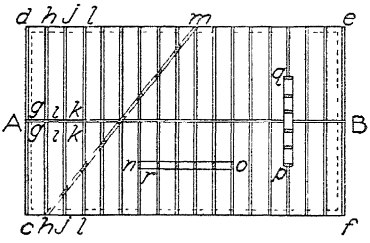


Fig. 169 Framing Plan of Small Roof

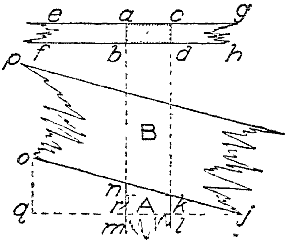


Fig 170 Connection of Studs and Rafters.

To take the simplest case first, let us consider the stud marked *r*. Since all the rafters have the same pitch or slope, all the studs in the partition *n o* will have the same bevel at the top, and if we find the bevel for one we can cut the bevel for all. Fig. 170 shows this stud drawn to a larger scale and separated from the rest; *a b c d* is a plan of the stud, and the rafter is shown at *e f g h*. We will take the distance *f h*, or the run of the part of the rafter shown, as one foot exactly. Now if A and B represent a side elevation of the rafter and stud looking in the direction shown by the arrow, the *run* of the part of the rafter shown is the distance *j q*, and the distance *q o* should be equal to the *rise* of the rafter in one foot. Let the rise in this case be nine inches. Then *k n* shows the bevel of the top of the stud. If the stud is a two by four stick, the distance *k r* is just four inches, or one-third of the run of the rafter, and consequently the distance *r n* is just three inches, or one-third of the rise of the rafter.

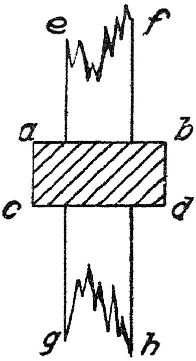


Fig. 171 Stud and Rafter.

In the case of the studs forming the partition *p q* in Fig. 169, the bevel is found in the same way, the only difference being that the rafter now crosses the stud, as shown in Fig. 171, where *a b c d* is the stud and *e f g h* is the rafter, both shown in plan.

In the case of the partition *h m*, Fig. 169, we have to deal with a somewhat more difficult problem because the rafter crosses the studs diagonally and the studs must be beveled diagonally on top so that the bevel will run from corner to corner instead of straight across the stud from side to side. An enlarged plan of one stud with the rafter running across it is shown in Fig. 172. Let *a b c d* be the stud and *e f g h* the rafter; *i j k l* shows the rafter in elevation looking in the direction shown by the arrow, and *a' b' c' d'* shows the stud as seen from this same direction. The corner *d* of the stud cannot be seen from this side and is shown as a dotted line in the figure. The rafter cuts across the corners of the stud at the points *a' b' c'* and *d'*, giving the bevel shown in the figure. This bevel may be cut by drawing any line all the way around the stud, square with the edges, as shown at *m n*, and laying off from this line on the edges of the stud the distances *a' a''*, *b' b''*, *c' c''*, and *d' d''*. Lines drawn across the faces of the stud connecting the points so obtained will give the exact bevel.

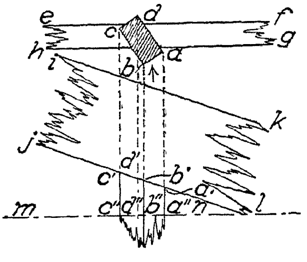


Fig. 172. Stud and Diagonal Rafter

SPECIAL FRAMING.

We have, in the preceding pages, considered the framing which enters into a building of light construction, such as an ordinary dwelling house, but there are certain classes of structures which call for heavier framing, or framing of special character. Among these may be mentioned *battered* frames, or frames with inclined walls; *trussed* partitions; *inclined* and *bowled* floors; special forms of reinforced beams and girders; the framing for balconies and galleries; timber trusses; towers and spires; domes, pendentives and niches; and vaults and groins. These subjects will be now taken up and discussed, and the methods employed in framing such structures will be explained.

Battered Frames. Sometimes it is necessary to build a structure with the walls inclined inward, so that they approach each other at the top, and so that the top is smaller than the bottom. This is the case with the frames which support water tanks or windmills. An elevation of one side of a frame of this kind is shown in Fig. 173 with a plan in outline at A. It will be seen that the corner posts *a a* are inclined and approach each other at the top, so that they are not perpendicular to the sill at the bottom. This means that the foot of the post, where it is tenoned into the sill, must be cut on a bevel, and the bevel must be cut diagonally across the post, from corner to corner, since the post pitches diagonally toward the center, and is set so that its outside faces coincide approximately with the planes of the sides of the structure as indicated in the plan shown in Fig. 174. The girts *b*, Fig. 173, will also have to have special bevels cut at their ends, where they are framed into the posts.

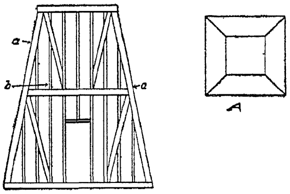


Fig 173. Battered Frame.

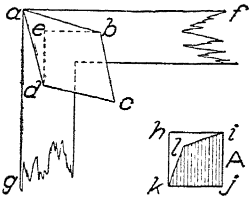


Fig. 174 Bevel of Corner Post.

After a corner post has been cut to the proper bevel to fit against the sill the section cut out at the foot will be diamond-shaped, as shown at *a b c d* in Fig. 174, which shows a plan of one corner of the sill. It will be noticed that the faces *a b* and *a d* of the post do not coincide with the edges of the sill *a f* and *a g*. If the structure is merely a frame and is not to be covered over with the boarding on the outside, it is not necessary that the outside faces of the post should coincide exactly with the planes of the sides of the structure, and in this case posts of square or rectangular section may be used, with no framing except the bevels and the mortises for the girts. If, however, the frame is to be covered in, the post must be *backed* so as to be able to receive the boarding.

The backing consists in cutting the post to such a shape that when the bevel is cut at the foot, the section cut out will be similar to that shown at *e b c d* in Fig. 174. The *backed* post must then be set on the sills so that the point *e* will come at the corner *a*. The face of the post *c b* will then coincide with the face of the sill *a f*. The post should be backed before the bevels are cut because setting it back the distance *a e* may make a difference in the required length between bevels. If the post was of square section before backing it will have, after backing, a peculiar rhombus-shaped section, as is shown at A in Fig. 174. Here *h i j k* shows the original square section, and *l i j k* shows the section after backing. These sections are taken square across the post perpendicular to the edges.

Fig. 175 shows how the amount of backing necessary in any particular case may be determined. Suppose that we have a case where the frame is not square in plan, as shown in Fig. 173, but is rectangular, one side being much longer than the other. In this case the diagonal of the frame formed by the sills will not coincide with the diagonal of the section of the post. Fig. 175 shows at A a plan of the post as it would appear if it were set up perpendicular to the sills. The sills are shown by the dotted lines. At B is shown an elevation of the post looking in the direction shown by the arrow *h*. The section shown at A is taken on the line *i j*. In the frame, however, the post is inclined toward the center, so that the section cut out at the foot of the post by the plane of the top of the sill will not be square with the edges of the post as is the section *i j*, but will be at an angle with them. Such a section is taken on the line *k l* and is shown at C.

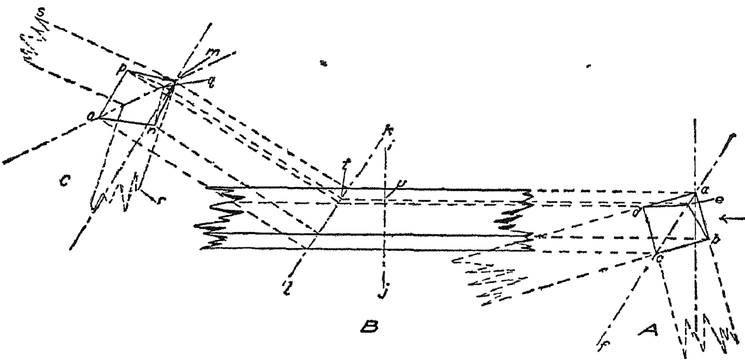


Fig. 175. Determining Amount of Backing.

The section of the post is shown by *m n o p* and the sill is indicated by the dotted lines. The post must now be backed so that this section will take the form shown by *q n o p*, the sides *p q* and *n q* being parallel to the sides of the sill *m r* and *m s*. This point *q* determines the position of the outside corner of the post after it has been backed and corresponds to the point *t* on the line *k l*. Then the line *t u* is the elevation of the outside corner of the post after backing, and the section *i j* cuts this line at *u*. The corner shown by the line *t u* must be diagonally opposite the inside corner of the post, so it must be indicated on the section shown at A by the point *e*. Then *e b c d* is the shape to which the post must be trimmed. This can be laid out on the square end of the rough post and it can then be trimmed to the correct shape. The backing will then be complete.

Fig. 176 shows how the foot cut for the inclined post may be obtained by using the steel square. In Fig. 173 it will be seen that the post *a* slopes toward the center in the elevation there shown, and it likewise slopes toward the center in the other elevations, either with the same pitch or with a different pitch. The result of the two slopes is to cause the post to slope diagonally. It is an easy matter to find the pitch in each elevation since it depends upon the size of the base and top, and the height between them. We then have the two pitches, the combination of which gives the true pitch, diagonally. They can, however, be treated separately. The square may be applied to the post, as shown in Fig. 176, with the rise on the blade and the run on the tongue, and a line may be drawn along the tongue. The post can then be turned over and the pitch shown in the other elevation may be laid off on the adjacent side in the same way with the rise on the blade and the run on the tongue of the square. Thus a continuous line *a b c d* may be drawn around the post and it can be cut to this line.

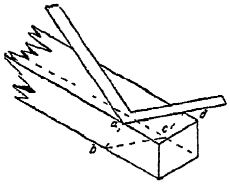


Fig. 176. Marking Foot Cut

Trussed Partitions. It is very often necessary to construct a partition in some story of a building above the first, and in such a position that there can be no support—as, for instance, a partition in the story below—beneath it. In this case the partition must be made self supporting in some way. The usual method is to build what is known as a trussed partition. This consists of a timber truss, light or heavy, according as the distance to be spanned is small or great, which is built into the partition and covered over with lathing and plastering or with sheathing.

Fig. 177 and 178 show two forms of trussed partitions which are in common use. The one shown in Fig. 177 may be employed for a solid partition, or a partition with a door opening in the middle, while the one shown in Fig. 178 is applicable where the wall must be pierced by door openings in the sides. The truss must be so designed that it will occupy as little space as possible in a lateral direction, so that the partition need not be abnormally thick. If possible it is best to make the truss so that it will go into a four-inch partition, but if necessary five or six-inch studding may be used and the truss members may be increased in size accordingly. The faces of the truss members should be flush with the faces of the partition studding, so as to receive lathing or sheathing.

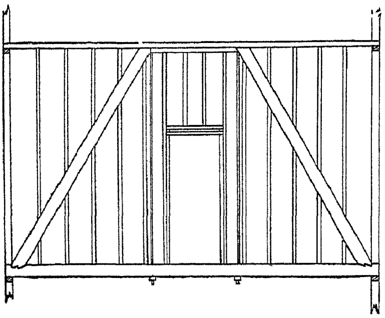


Fig. 177. Trussed Partition.

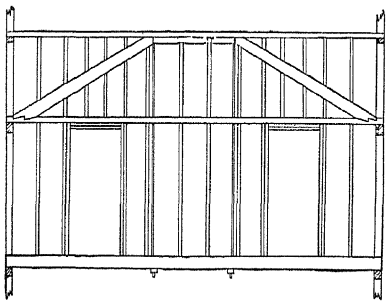
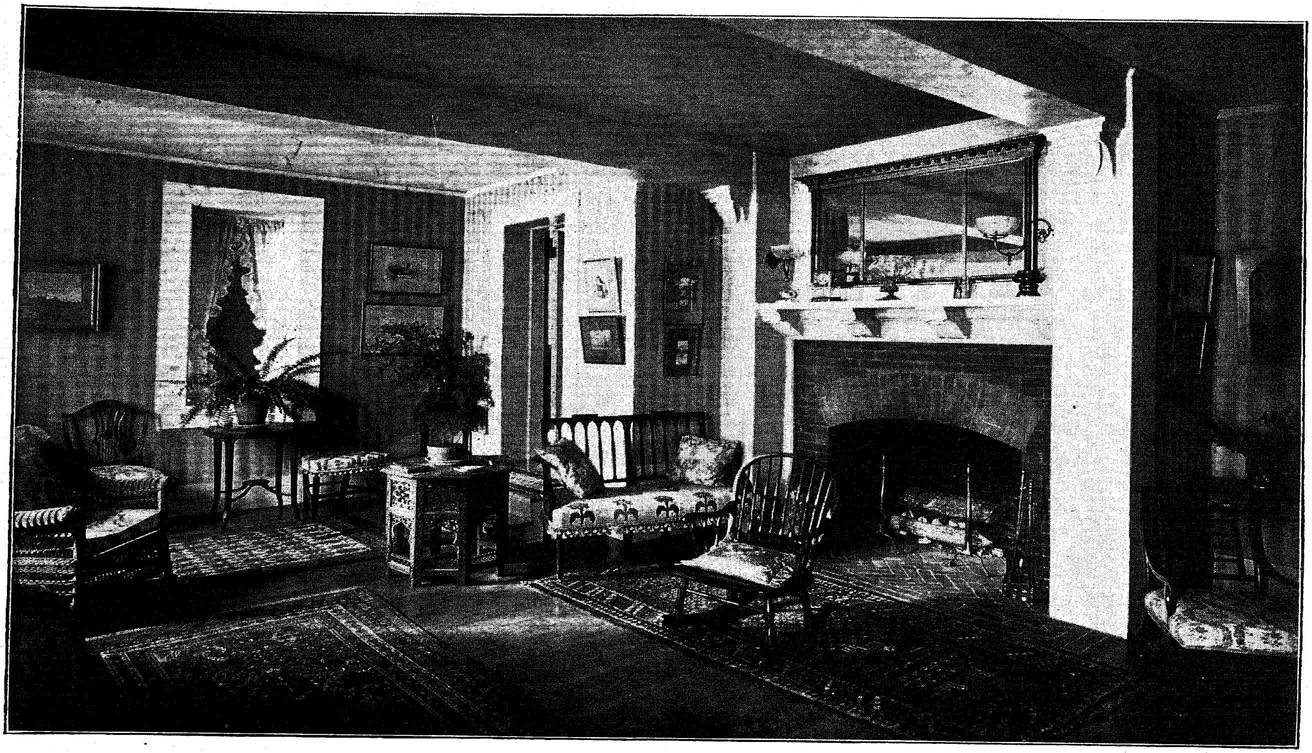


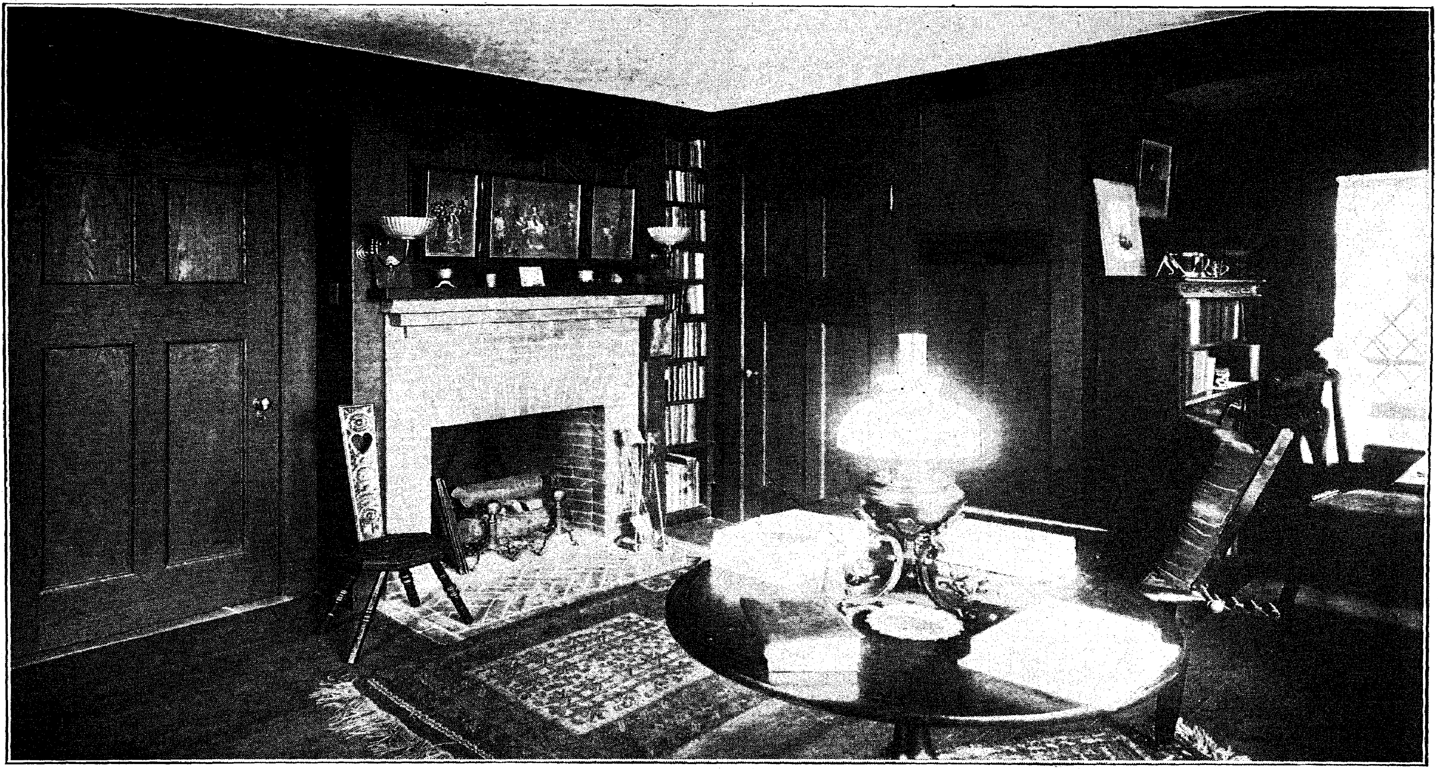
Fig. 178. Trussed Partition.

The size of the truss members depends entirely upon the weight which the partition is called upon to carry. Besides its own weight a partition is often called upon to carry one end of a set of floor joists, and sometimes it supports columns which receive the whole weight of a story above. In any case the pieces must be very strongly framed or spiked together, and sound material, free from shakes and knot holes, must be used.

Inclined and Bowled Floors. In any large room which is to be used as a lecture hall, the floor should not be perfectly level



LIVING ROOM IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York
For Plans and Exterior, See Page 106; for Dining Room, See Page 138.



LIBRARY IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York.

throughout, but should be so constructed as to be higher at the back of the room than it is at the front. The fall of such a floor from back to front should be not more than three quarters of an inch in one foot, and a fall of one-half an inch in one foot is much better. If the floor has a greater slope than this it becomes very noticeable when anyone attempts to walk over it.

The simplest way to arrange for the slope is to construct what is known as an *inclined* floor, which rises steadily from front to back so that a line drawn across it from side to side, parallel to the front or rear wall of the room, will be level from end to end. There are two methods of building an inclined floor, the difference between them being in the arrangement of the girders and floor joists. The two methods are shown in Figs. 179 and 180.

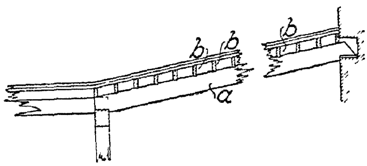


Fig 179 Inclined Floor

Fig. 179 shows the arrangement when it is necessary to have the girders run from the back to the front of the room, parallel to the slope of the floor. In this case the girders *a* are set up on an incline, and the joists *b* resting on top of them, are level from end to end. Each line of joists is at a different elevation from the lines of joists on each side of it. The floor laid on top of the joists will then have the required inclination. The slope of the girders must be the same as the slope required for the finished floor.

Fig. 180 shows the arrangement when it is desired that the girders shall run from side to side of the room, at right angles to the direction of the slope of the floor. The joists *a* will then be parallel to the direction of the slope, and are inclined to the horizontal, while the girders *b* are level from end to end. Each line of girders is at a different elevation from every other line of girders, and these elevations must be so adjusted that the joists

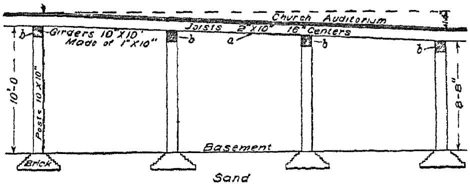


Fig. 180 Inclined Floor.

resting on top of the girders will slope steadily from end to end.

When a simple inclined floor is employed, the seats must be arranged in straight rows, extending across the room from side to side, so that each line of seats may be level from end to end. This arrangement is not always desirable, however, and it is often much better to have the seats arranged in concentric rings all facing the speaker's platform. In this case a *bowled* floor must be built. A bowled floor is so constructed that a segment of a circle, drawn on the floor from a center in the front of the room, on, or near, the speaker's platform, will be perfectly level throughout its length. This means that the floor must pitch upward in all directions from the speaker's platform or, in other words, it must be *bowled*. There are two methods of constructing a floor of this kind. The simplest way is to build first an ordinary inclined floor, which slopes from the front to the back of the room, and then to build up the bowled floor with furring pieces. This method should always be followed when it is necessary to keep the space beneath the lecture hall free from posts or columns.

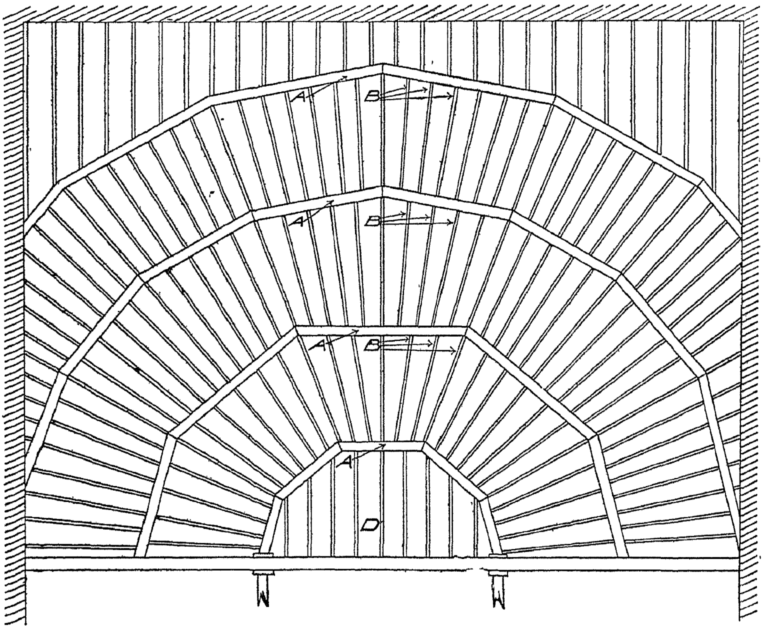


Fig 181. Framing Plan of Bowled Floor.

The second method is to arrange girders, as shown in the framing plan of a bowled floor in Fig. 181. These girders A A are tangent to concentric circles which have their center at the speaker's platform, and each line of girders is at a different elevation. The elevations of the different lines of girders are so adjusted that the floor joists B B which rest on them will slope steadily upward as they recede from the platform. The girders may be supported on posts beneath the floor of the hall, and if the space under the floor is not to be used for another room, this is a very good method to employ.

Immediately around the platform there will be a space D, the floor of which will be level, and the slope will start several feet away from the platform.

Heavy Beams and Girders. For ordinary frame buildings, there will be no difficulty in obtaining timbers large enough for every purpose, but in large structures, or in any building where heavy loads must be carried, it is often impossible to get a single stick which is strong enough to do the work. In this case it becomes necessary to use either a steel beam or a trussed girder of wood, or to build up a compound wooden girder out of a number of single sticks, fastened together in such a way that they will act like a single piece.

Steel beams are very often employed for girders when a single timber will not suffice, and although they are expensive, the saving in labor helps to offset the extra cost of the material.

Wherever wooden joists or girders come in contact with a steel beam they must be cut to fit against it. The steel shape most commonly employed is the I-beam, and the wooden members must be cut at the ends so as to fit between its flanges. This is shown in Fig. 182. The joist *b* is supported on the lower flange of the I-beam *c* and the strap *a* prevents it from falling away from the steel member. The strap is bolted or spiked to the wooden beam and is bent over the top flange of the steel beam as shown. If two wooden beams frame into the steel beam opposite each other, a straight strap may be used, passing over the top of the steel beam and fastened to both the wooden beams, thus holding them together. If a better support is desired for the end of the wooden beam, an angle may be riveted to the web of the steel I-beam, as shown in Fig. 183, and the end of the wooden joist may be supported on the angle. This is an expensive detail, however, and it is seldom necessary.

If a timber is not strong enough to carry its load, and if it is not desirable to replace it with a steel beam, it may be strengthened by trussing. There are two methods of trussing beams; by the addition of compression members above the beam, and by the addition of tension members below it. The first method should be employed whenever, for any reason, it is required that there be no projection below the bottom of the beam itself. The second method is the one most commonly used, especially in warehouses, stables, and other buildings where the appearance is not an important consideration.

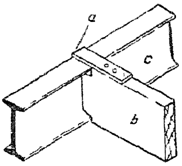


Fig. 182 I-Beam and Wooden Joist

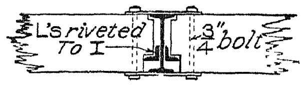


Fig. 183 I-Beam Construction.

In Fig. 184 is shown a beam which is trussed by the first method, with compression pieces *a a a* above the beam. All the parts are of timber excepting the rods *b b* which may be of wrought iron or steel. The beam itself is best made in two parts *e e* placed side by side, as shown in the section at A, with the parts *a a* fitting in between them. The section shown at A is taken on the line *c d*. The depth of the girder may be varied to suit the conditions of each case. In general the deeper it is made the stronger it becomes, provided that the joists are made sufficiently strong.

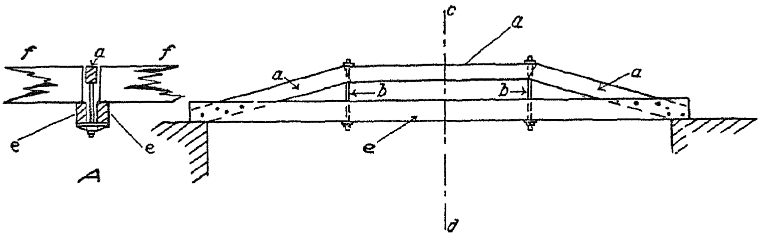


Fig. 184 Trussed Beam

Usually girders of this kind are made shallow enough so that they will be contained in the thickness of the floor and will not project above it. A slight projection below the ceiling is not a serious disadvantage. The floor joists *f f* may be supported on the pieces *e e*, as shown at A.

In Figs. 185 and 186 are shown examples of girders which are trussed by the second method, with tension rods *d d* below the beam. These rods are of wrought iron or steel, and the struts *a a* are of cast iron. The struts may be made of wood if they are short, or if the loads to be carried are not heavy. Sometimes the girders are made very shallow, and the struts *a a* are then merely wooden blocks placed between the beam *c* and the rod *d* to keep them apart. The girder shown in Fig. 185 is known as a *king-post* trussed beam, while the one shown in Fig. 186, with two struts instead of one, is known as a *queen-post* trussed beam. The beam itself *c* may be made in two pieces side by side with the rods and the struts fitting in between them, or it may be a single stick, and the rods may be made in pairs, passing one on each side of the beam. In the latter case the struts would simply bear against the bottom of the beam, as shown in the illustrations, being fastened to it by bolts or spikes, so that they will not slip sideways.

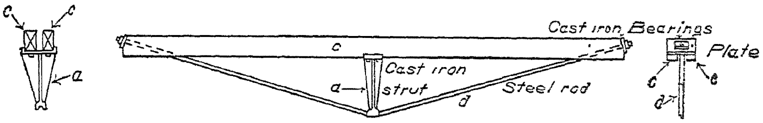


Fig 185 King Post Trussed Beam

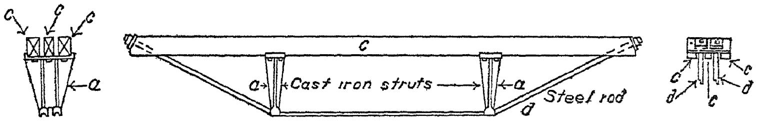


Fig. 186. Queen Post Trussed Beam.

It sometimes happens that a heavy girder is required in a situation where trussing cannot be resorted to, and where steel beams cannot readily be obtained. In this case the only resource is to build up a compound beam from two or more single pieces. A girder of this kind can be constructed without much difficulty, and can be so put together as to be able to carry from eighty to ninety per cent of the load which a solid piece of the same dimensions will bear. There are many ways of combining the single timbers to form compound beams, some of the most common of which will be described.

The most simple combination is that shown in Fig. 187. The two single timbers are bolted together side by side, with sometimes a small space between them. The bolts should be spaced about two feet apart and *staggered*, as shown, so that two will not come side by side. Usually bolts three-quarters of an inch in diameter are used.

In Fig. 188 is shown a modification of this girder known as a *flitch-plate girder*. It has a plate of wrought iron or steel, inserted between the two timbers, and the whole is held firmly together by bolts. The size of the plate should be in proportion to the size of the timbers, so as to make the most economical combination.

If we have two pieces of timber out of which we wish to make a compound girder, it is almost always possible to get a stronger combination by placing them one on top of the other, than by placing them side by side. This is because the strength of a beam varies as the *square of its depth*, but only *directly as its width*. For this reason most compound girders are composed of single sticks placed one above the other. The tendency is for each piece to bend independently, and for the two parts to slide by each other, as shown in Fig. 189. This tendency must be overcome and the parts so fastened together that they will act like a single piece. There are several methods in common use by which this object is accomplished.

Fig. 190 shows the most common method of building up a compound girder. The timbers are placed together, as shown, and narrow strips of wood are nailed firmly to both parts. The strips are placed close against each other and have a slope of about forty-five degrees, sloping in opposite directions, however, on opposite sides of the girder. It has been claimed that a built up girder of this kind has a strength ninety-five per cent as great as the strength of a solid piece of the same size, but it is very doubtful whether this is true in most cases. Actual tests seem to indicate that such girders have an efficiency of only about seventy-five per cent. They usually fail by the splitting of the side strips, or the pulling out and bending of the nails, but seldom by the breaking of the main pieces. It is, therefore, essential that the strips should be very securely nailed to each of the parts which make up the girder, and that they should also be carefully selected so that only those pieces which are free from all defects may be used.

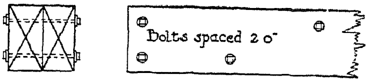


Fig. 187. Compound Beams.

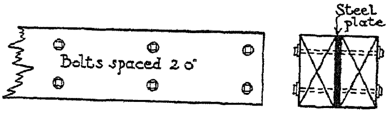


Fig 188 Flitch-Plate Girders.

These girders are liable to considerable deflection, and should not be used in situations where such deflections would be harmful.

In Fig. 191 is shown another form of girder with the parts notched, as shown, so as to lock together. This prevents them from slipping by each other. Bolts are employed to hold the parts together, so that the surfaces will always be in close contact.

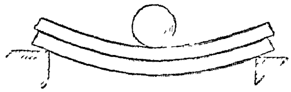


Fig 189 Flexure of Compound Beams.

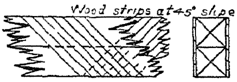


Fig. 190 Compound Girder.

While this form of girder is very easily constructed, it has many disadvantages. A great deal of timber is wasted in cutting out the notches, as these must be deep enough to prevent crushing of the wood at the bearing surfaces, and thus the full strength of the sticks is not utilized. Moreover, it is apt to deflect a good deal, and its efficiency is not so great as that of other forms. On the whole it is considered to be greatly inferior to the form of girder previously described.

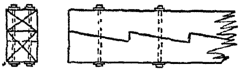


Fig 191. Notched Beam

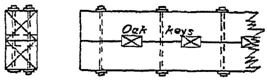


Fig. 192. Keyed Beam,

The form of compound beam which is almost universally considered the best is that shown in Fig. 192. This is known as the *keyed beam*, its characteristic feature being the use of *keys* to keep the parts from sliding on each other. The strength of a keyed beam has been found by actual experiment to be nearly ninety-five per cent of the strength of the solid timber, while the deflection when oak keys were used was only about one-quarter more than the deflection of the solid beam. By using keys of cast iron instead of wood this excess of deflection in the built-up girder can be reduced to a very small percentage. The keys should be made in two parts, each shaped like a wedge, as explained in connection with the keys for tension splices, and should be driven from opposite sides into the holes made to receive them, so as to fit tightly. They should be spaced from eight to sixteen inches apart, center to center, according to the size of the timbers, and should be spaced more closely near the ends of the beam than near the middle. In the center of the span there should be left a space of four or five feet without any keys.

Balconies and Galleries. In churches and lecture halls it is almost always customary to have one or more balconies or galleries, extending sometimes around three sides of the main auditorium, but more often in the rear of the room only. These galleries are supported by the wall at the back and by posts or columns in front, and the framing for them is usually a simple matter.

Fig. 193 shows a sectional view of a gallery frame, as they are commonly constructed. There is a girder *a* in front, which rests on top of the columns *t*, and supports the lower ends of the joists *b*, forming the gallery floor. The size of these pieces will depend upon the dimensions of the gallery, the spacing of the columns which support the girders in front, and various other considerations. Usually joists two by ten or three by twelve, and girders eight by ten or ten by twelve will be found to be sufficiently strong. The joists should be spaced from fourteen to twenty inches, center to center. Very often cast iron columns are employed to support the girders. At the top, where the joists rest on the wall, they should be cut, as shown in the figure, so that they may have a horizontal bearing on the masonry, and at least every second joist must be securely anchored to the wall, as is the one shown. Usually galleries are made with straight fronts, but if it is desired that the seats should be arranged in concentric rings, all facing the speaker, the joists may be placed so as to radiate from the center from which the seats are to be laid out.

The seats are arranged in steps, one above the other, and the framing for the steps must be built up on top of the joists, as shown in the figure. Horizontal pieces, *c c c* usually two by four or three by four in size, are nailed to the joists at one end, and at the other end are supported by upright pieces *d d d*. The uprights are either two by four pieces resting on top of the joists or strips of board, one inch to one and one-half inches thick, which are nailed to the sides of the joists and to the sides of the horizontal pieces. Both methods are shown in the figure. If boards are used, they should be placed on both sides of the joists. Great care should be taken to see that the horizontal pieces are truly horizontal.

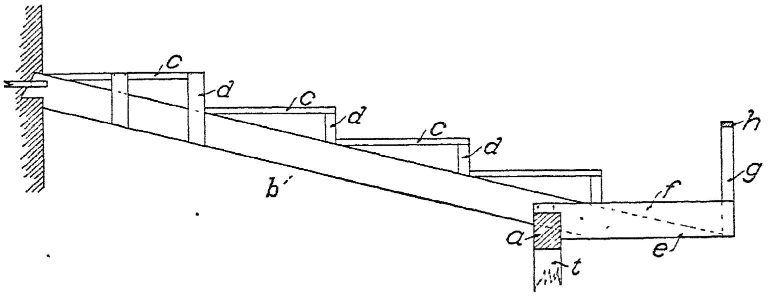


Fig 193 Section of Gallery Frame

Balconies and galleries almost always project a considerable distance beyond the line of columns which support the lower ends of the joists. This projection varies from three feet to ten or twelve feet. If the overhang is not more than five feet, it can be supported by extending the joists beyond the girder, as is shown in Fig. 193. A strip of board, *e*, about one and one-half inches thick, is nailed to the side of the joist, and a furring piece *f* is nailed on top of the joist at its lower end to make it horizontal. The railing at the front of the gallery should be about two feet high, and may be framed with two by four posts, *g* having a cap *h* of the same size on top.

If the overhang of a gallery is more than about five feet it must usually be supported by a brace, as shown in Fig. 194.

The brace *a* is nailed to the post *b* and to the overhanging joist *c*, or may be framed into these pieces. If the construction is very light, the brace may consist of strips of board nailed to the sides of the joists, but in heavy work it must be a timber of a good size, well framed into both the post and the joists. These braces can only be placed at points where there are posts, and to support the ends of the joists which come between the posts there must be a girder *d* running along the front of the gallery and supported by the braced cantilevers at the points where posts are placed.

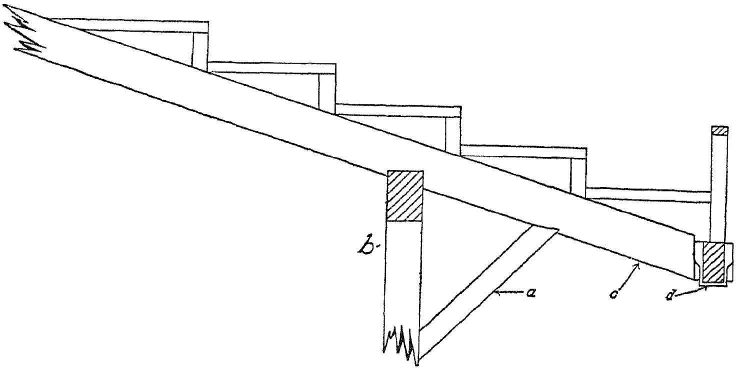


Fig 194 Support for Extension Beyond Girder

Timber Trusses. In the discussion of roofs and roof framing, only those were considered which could be framed with ordinary rafters, spaced from one foot to two feet apart, between centers, but it is very often necessary to build roofs of larger span, for which ordinary rafters, even if supported by dwarf walls and collar beams, are not sufficiently strong. In this case a different method of framing is employed. Instead of a number of rafters spaced fairly close together, and all of equal strength, we have a few heavy *trusses*, placed at intervals of ten feet or more, and spanning the entire distance between the side walls. On top of the trusses are laid *purlins* running parallel to the side walls, which

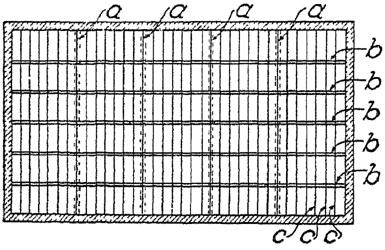


Fig. 195. Timber-Trussed Roof.

in their turn support the common rafters. There may be one or more purlins in each slope of the roof, depending upon the size of the span. This arrangement is shown in plan in Fig. 195, in which *a a* are the trusses, *b b* are the purlins, and *c c c* are the common rafters.

There are many different kinds of trusses which are in common use, for various kinds of buildings, differing from each other chiefly in the arrangement of the tension and compression pieces of which they are composed. Some are built entirely of timber, while in others timber is employed only for the compression pieces, and wrought iron or steel for the tension pieces. Fig. 196 shows what is known as a *king post* truss. Its distinguishing feature in the member *a*, called the *king post;* *b b b* are the purlins, and *e e* the rafters resting on them. Two different methods of placing the purlins are illustrated in this figure. As will be readily seen, some of them are set so that their longer dimension, in cross section, is vertical, while others are set so that the longer dimension is at right angles to the rafters. Both of these methods are commonly employed. The tension members *c c* are merely for the support of the lower chord or *tie beam d.*

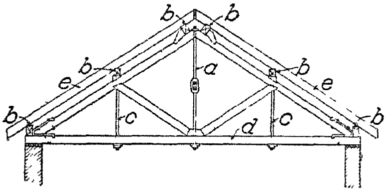


Fig 196 King-Post Truss

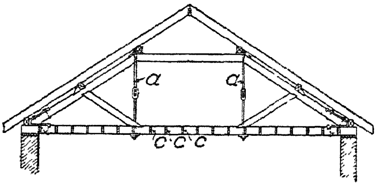


Fig. 197. Queen-Post Truss.

Fig. 197 shows a modification of the king post truss which is called the *queen post* truss. Here there are two *queen posts a a* in place of the single king post. This figure also shows how a floor or ceiling may be supported on the lower chord or *tie beam* of the truss. The joists *c c c* are hung from the chord by means of stirrup irons or patent hangers. The queen post truss is somewhat more popular in building work than is the king post truss, but both are frequently employed in halls, warehouses, and stables where an ornamental truss is not required, and also in churches and audience rooms where they are to be concealed by other finish.

In Fig. 198 is shown a *Fink* truss, which is a very popular form, especially for trusses built of steel. It has neither king post or queen posts, and the *tie beam a* is of iron instead of timber. It is a simple and cheap form of truss for any situation where there is no floor or ceiling to be carried by the lower chord. The struts *b b* may be of wood or of cast iron. It will be seen that the truss consists essentially of two trussed rafters set up against each other, with a tie rod *a* to take up the horizontal thrust.

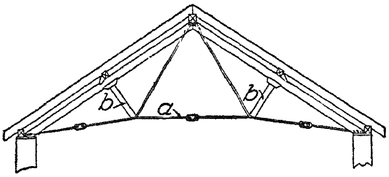


Fig 198 Fink Truss

Beside the forms of trusses described above, there are other forms which are used in churches and chapels where *open timber* work is required, and where they will not be concealed by other finish, but will be made ornamental in themselves. Among these the most common forms are the so-called *scissors* truss and the *hammer beam* truss.

The *scissors* truss is shown in Fig. 199. It has no tie beam, and therefore it may exert considerable thrust on the walls of the building, which must be taken care of by buttresses built up on the outside of the wall. This is perhaps the most simple form of truss which can be used when an open timber truss is required. All the parts are of wood. If desired, an iron tie rod may be inserted between the two wall bearings of the truss, so as to diminish the thrust on the walls, and this need not detract seriously from the appearance of the open timber work.

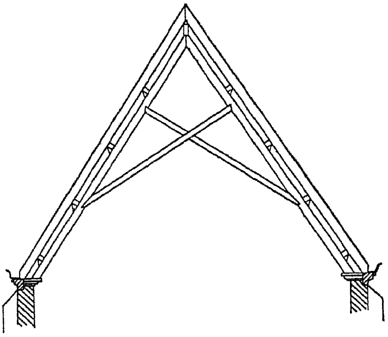


Fig 199. Scissors Truss.

A very popular form of truss for use in churches is the hammer beam truss mentioned above. This is shown in Fig. 200. On the left is shown the framework for the truss, while on the right is shown the way in which it may be finished. Its characteristic feature is the hammer beam *a*.

The sizes of the pieces can only be determined by calculation or experience, and depend entirely upon the span of the truss and the loads to be carried, which are different for different parts of the country. It is common practice to insert a tie rod between the points *b* and *c* to take up some of the thrust which would otherwise come on the walls. All parts of the framework must be securely bolted or spiked together so as to give a strong, rigid foundation for the decoration, and this should be regarded merely as decoration and should not be considered as strengthening the truss in any way.

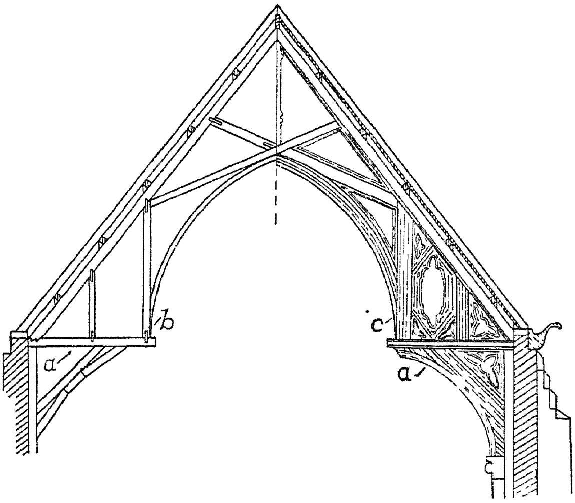


Fig 200 Hammer Beam Truss

Truss Details. There are several ways of supporting the purlins on wooden trusses, but the method illustrated in Fig. 201 is one of the best as well as the most frequently employed. A block of wood *a* is set up against the lower side of the purlin, and prevents it from turning about the corner *b*, which it has a tendency to do. The block is set into the chord of the truss to a depth sufficient to keep the purlin from sliding downward as it receives the weight from the rafters *c*. This figure also shows the most simple method of framing a strut into the chord of a truss. The strut *c* is set into the chord *d* far enough to hold it in place. If it is perpendicular to the chord, it need not be so set into it, if the pieces are well nailed together, because in this case there is no tendency for the strut to slide along the chord. Care should be taken not to weaken the chord too much in cutting these mortises.

In Fig. 202 are shown the two most common methods of forming the joint between the top chord and the tie beam of a truss. The connection shown at A depends upon the bolts for its strength, while that shown at B depends upon the wrought iron straps *a*, which are bent so as to engage notches cut in the tie beam *b*. The piece *c* is very often added beneath the tie beam, at the bearing, to strengthen it at this point, where it is subject to considerable bending stress. The block *d* is merely for filling and to protect the bolts when they pass between the chord and the tie beam. It may be omitted in many cases. The plate *f* is placed between the nuts or bolt heads and the wood to prevent the crushing of the latter. Washers should be used with all bolts for this purpose.

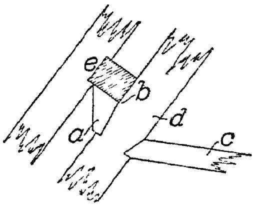


Fig. 201. Support for Purlins

Fig. 203 shows how the joint at the center of the tie beam of a king post truss, or any joint between two struts, may be formed. The tie beam is shown at *a*, and *b b* are the struts. The blocks *c*, set between the struts, receive the thrust from them. They should be notched into the tie beam *a*, deep enough to take care of any inequality between the thrusts from the two struts, which have a tendency to balance each other. This block is often made of cast

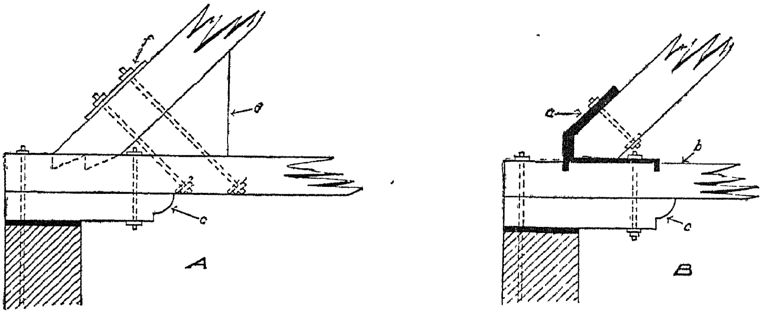


Fig 202 Joints at Top Chord and Tie Beams

iron. It may be omitted altogether, in which case the struts will come close together and bear against each other. The rod *d* is the king post which supports the tie beam *a* at this point. It is often made of wood, and sometimes the struts *b b* are framed into it instead of being framed into the tie beam *a*.

Fig. 204 shows a form of connection for the peak of a truss, where the two top chords or *principal rafters* come together. The plate *a* acts as a tie to keep these members in place, as does the bent plate *b*, also. The plate *b*, moreover, prevents the crushing of the timber by the nut of the king post tie rod. The purlin *c* supports the rafters and is hollowed out at the bottom to admit the nut *d*. The two principal rafters bear against each other and must be cut so that the bearing area between them will be sufficient to prevent the crushing of the timber. In light trusses the king post *e* is often made of wood and is carried up between the principal rafters so that these members bear against it on each side. If this construction is adopted it must be remembered that the post is a tension member, and is held up by the principal rafters, and these pieces must be mortised into it in such a way as to accomplish this result.

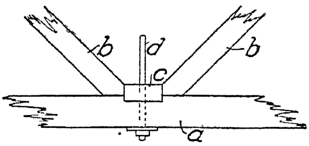


Fig 203 Joint at Center of Tie Beam

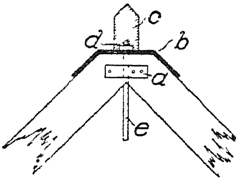


Fig 204 Peak of Truss

There are a great many different ways of arranging the details for wooden trusses, each case usually requiring details peculiar to itself and unlike those for any other case. There are, therefore, no hard and fast rules which can be laid down to govern the design of these connections. A perfect understanding of the action of each piece and its relation to all the other pieces is the only thing which will insure an economical and appropriate design. The aim should always be to arrange the details so that there will be as little cutting of the pieces as possible, and so that the stresses may pass from one to the other without over-straining any part of the work.

Towers and Steeples. Towers are a very common feature in building construction, ranging in size from the small cupola seen almost invariably on barns and stables, to the high tapering spire which is the distinguishing mark of the country church.

They have roofs of various shapes, some in the form of pyramids, with four, eight, or twelve sides, some of conical form, and others bell-shaped or having a slightly concave surface.

The construction of all these forms of towers is much the same, consisting of an arrangement of posts and braces which becomes more elaborate as the tower or steeple becomes larger. The bracing is the most important consideration, because the towers will be exposed to the full force of the wind and must be able to stand the great strain to which they are subjected.

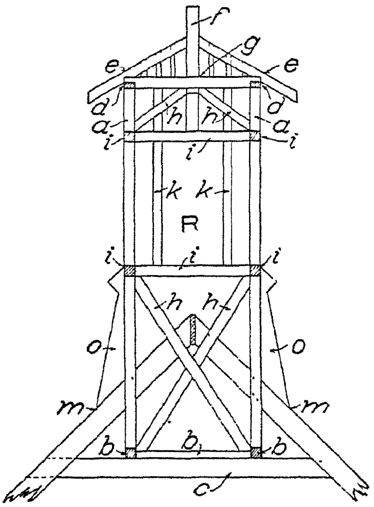
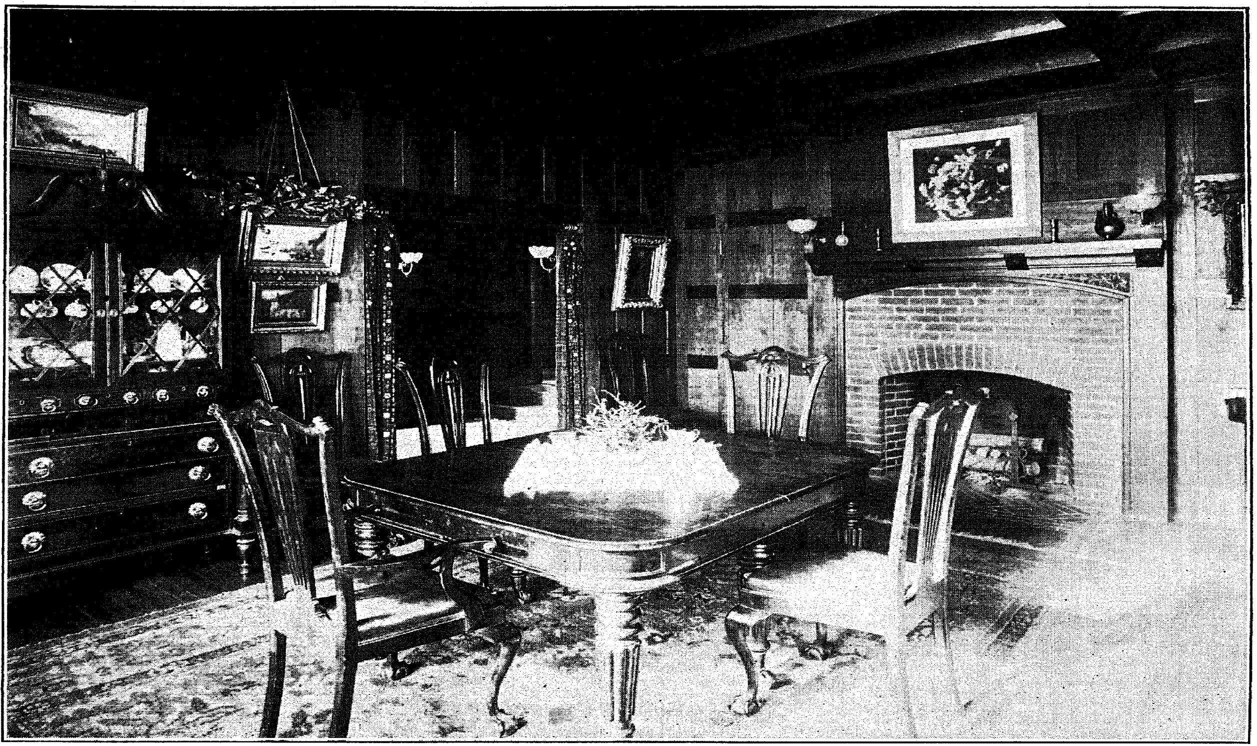
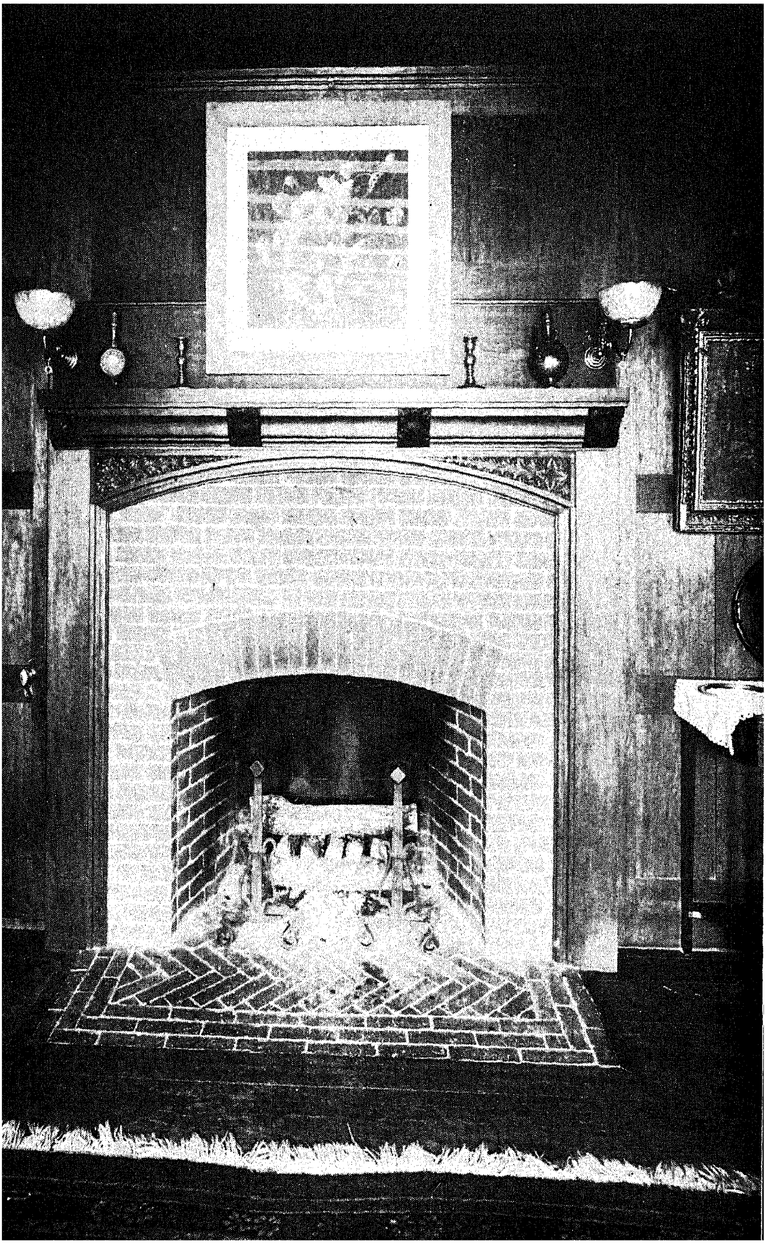


Fig 205. Frame for Cupola

Fig. 205 shows a section through the frame of a simple cupola. It has posts *a a* at each corner, which rest at the bottom on the sills *b b*. The sills are supported on extra heavy collar beams *c*, which are very securely spiked to the rafters of the main roof *m m*. The corner posts extend clear up to the main plate *d d*, which supports the rafters *e e* of the cupola. There are hip rafters at the corner of the roof, which bear at the top against a piece of scantling *f* placed in the center of the roof. This scantling extends above the roof surface far enough to receive some kind of metal finial which forms the finish at the extreme top of the cupola; and at the bottom it is firmly fastened to the tie *g* which is cut in between the plates. The braces *h h h h* stiffen the frames against the wind. Girts *i i* are cut in between the corner posts and form the top and bottom of the slat frame opening R, besides tieing the posts together. The sides of the opening for the slat frame are formed by the vertical studs *k k*. The rafters of the



DINING ROOM IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York
For Plans and Exterior, See Page 106; for Living Room, See Page 122.



FIREPLACE IN DINING ROOM OF HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York.

main roof *m m* are placed close up against the corner posts on the outside, and the posts may be spiked to them. The pieces *o o* are of plank two inches thick, and are simply furring pieces placed at intervals of a foot and a half to two feet all around the cupola to give the desired shape to the bottom part. The size of the pieces will depend upon the size of the cupola. The posts may be four by four inches or six by six inches, and the braces, girts and intermediate studding may be three by four inches or four by six inches.

Other towers are framed in a manner similar to that described for cupolas. There is always a base or drum, with posts at the corners and with the walls filled in with studding, which supports a plate at the top. The rafters forming the tower roof rest at the foot on this plate, and at the top they bear against a piece of scantling which is carried down into the body of the tower for a considerable distance and is there fastened to a tie passing between rafters on opposite sides. This is shown in Fig. 206. The tie *a* is securely nailed to the rafters at each end, and to the scantling in the middle. The scantling is cut so as to have as many faces as the roof has sides, four for a square hip roof, eight for an octagon roof, and so on. Each face receives one of the hip rafters and the intermediate rafters are framed in between them. If the roof is conical or bell-shaped, as shown in the figure, the scantling at the top may be cylindrical in form. Although the roof shown is bell-shaped, the rafters are not cut to fit the curve. They are made straight and are filled out by furring pieces *b b*. Pieces of plank *c c* are cut in between the furring pieces, as shown, so as to give a nailing for the boarding, and they are cut to the shape of segments of circles, so as to form complete circles around the tower when they have been put in place. If a tower of this shape is to be built, leaving a number of

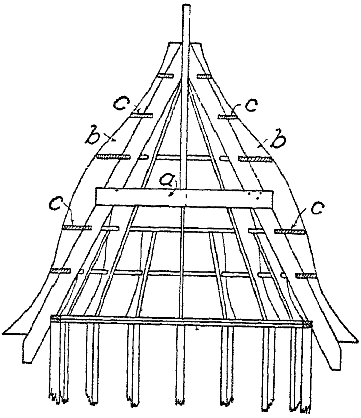


Fig 206 Frame for Tower

faces and hips, the curve of the hip rafters will not be the same as the curve shown by a section through one of the faces of the tower. In order to find the true curve for the hip rafters the same method is followed as was explained for the hip rafter in an ogee roof over a bay window, using the principle that any line drawn in the roof surface parallel to the plate is horizontal throughout its length. By this means any number of points in the curve of the hip rafter may be obtained and the curve for the hip may be drawn through them. Thus a pattern for the hip rafter may be obtained.

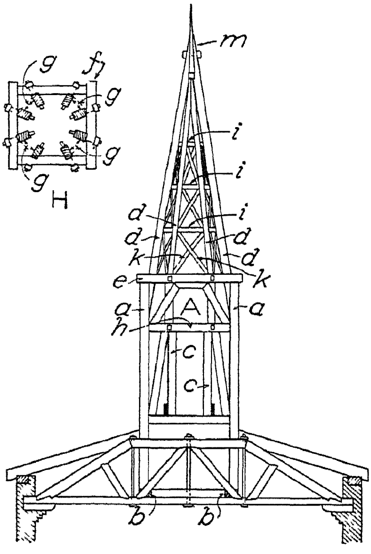


Fig. 207 Frame for Church Spire.

Fig. 207 shows the method of framing a church spire, or other high tapering tower. The drum A is square and is supported by the posts *a a*, one at each corner, which rest on the sills *b b*. The sills are supported by the roof trusses of the main roof. The corner posts extend the full height of the drum and are strongly braced in all four faces, with intermediate vertical studding *c c* between them to form the framework for these faces. The spire itself may rest on top of this square drum or there may be another eight- or twelve-sided drum constructed on top of the first on which the spire may rest. This depends upon the design of the spire. The hip rafters *d d d d* do not rest directly on top of the drum, however, as this arrangement would not give sufficient anchorage for the spire. They are made so as to pass close inside the plate *e* at the top of the drum and are securely bolted to this plate with strong bolts. This is shown at H which is a plan of the top of the drum, showing the hip rafters in place. The plate is shown at *f* and the hip rafters at *g*. The rafters extend down into the body of the drum as far as the girt *h* (shown in the elevation) to which they are again securely spiked or bolted, being cut out at the foot so as to fit against the girt. In this way a strong anchorage for the spire is obtained.

Horizontal pieces *i i i i* are cut in between the hip rafters at intervals throughout the height of the spire, and braces *k k* halved together at the center where they cross each other are firmly nailed to the rafters at each end. These braces are needed only in lofty spires, which are likely to be exposed to high winds. At the top the hip rafters bear against a piece of scantling *m* the same as in the other towers. If a conical spire is called for in the design, the horizontal pieces *i i i* must be cut to the shape of segments of circles, and in this case the rafters are no longer hip rafters. The horizontal pieces *i i* will receive the boarding which will form a smooth conical surface.

The spire above the drum is usually framed on the ground before being raised to its final position. It may then be raised part way and supported by temporary staging while the top is finished and painted, after which it may be placed in position on top of the drum.

Domes. Timber domes have been built over many famous buildings, among which may be mentioned St. Paul's Cathedral at London, and the Hotel des Invalides at Paris. While these structures are domical in shape they are not, strictly speaking, domes, because they do not depend for support upon the same principle which is employed in the construction of masonry domes. They are, correctly speaking, arrangements of trusses of such a shape as to give the required domical form to the exterior of the roof.

Fig. 208 shows such a truss supported at either end on a masonry wall as shown. Fig. 209, which is a plan of the framing of this roof, shows how the trusses or *bents* may be arranged. There are two complete bents, *a b* and *c d*, like the one shown in the elevation, Fig. 208, which intersect each other at the center. The king post *a*, in the elevation, is common to both bents, and the tie beams *b* are halved together where they cross. These two bents divide the roof surface into four quarters which are filled in by shorter ribs, as indicated in the plan, Fig. 209. The posts *c* in Fig. 208 carry all the weight of the roof to the walls and are braced by means of the pieces *d*. The rounded shape is given to the exterior and interior of the bent by pieces of plank bent into position as shown. The whole is covered with boarding which is cut to a special shape so that it can be bent into place. The methods of applying the boarding to domical roofs will be explained in connection with other rough boarding.

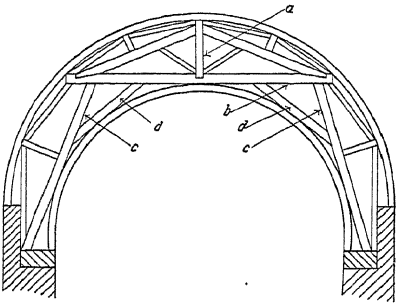


Fig. 208 Frame for Dome.

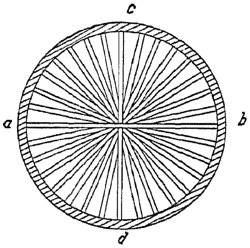


Fig 209 Plan of Dome Framing

The arrangement of trusses or bents described above is suitable for a plain domical roof without a lantern or cupola on top, but very frequently this feature is present in the design, and the roof must be framed to allow for it. There are several different ways of arranging the trusses so as to leave an opening in the center of the roof for the lantern. Fig. 210 shows a very good arrangement. Four trusses, *a a a a*, span the entire distance between the walls, and are placed as shown in the figure, so as to leave the opening B in the center. Four half trusses *c c c c* are

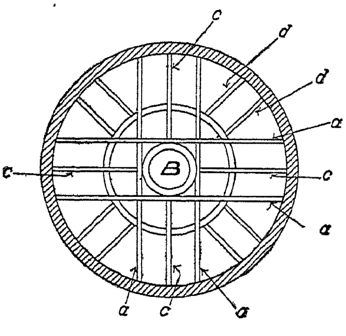


Fig. 210. Plan of Dome Framing with Central Opening.

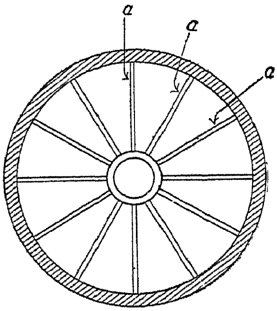


Fig 211. Plan of Dome Framing with Opening.

inserted between them, as shown, and eight shorter ribs *d d* are employed to fill in the rest of the space.

Fig. 211 shows another arrangement, providing for a lantern at the center. There are a number of ribs, *a a a*, twelve in the figure, all radiating from the center where there is a circular opening for the lantern or cupola. In Fig. 212 is shown a section through a domical roof framed in this way, showing an elevation of one of the ribs. The rib is so constructed as to be entirely contained in the restricted space between the lines of the exterior and interior of the roof.

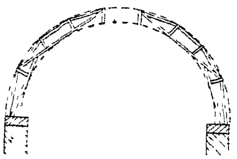


Fig 212 Section of Dome Framing

Pendentives. In the preceding paragraphs we have considered the subject of domical roofs covering buildings of circular plan, which is the simplest possible case, but unfortunately not the most usual one. It very often happens that a domical roof must be erected over a building which is square or rectangular in plan, in which case a new and difficult problem must be considered, namely, that of the pendentives. A horizontal section taken through a dome must in every case show a circle or possibly an ellipse. If, then, we consider the horizontal section cut from a domical roof by the plane of the top of the wall, it must usually be a circle and cannot exactly coincide with the section cut from the wall of the building by the same plane, unless the building is circular in plan. This is shown in Fig. 213 in which A B C D represents the section cut from the wall of the building by a horizontal plane, and the circle E F G H represents the section which would be cut from a domical roof covering the building if the framing for the dome were carried down to meet this plane all the way around.

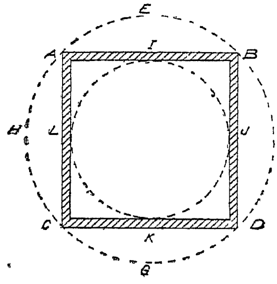


Fig. 213. Dome on Rectangular Walls.

In order to cover every part of the building, the dome must be large enough to include the corners, and if made sufficiently large for this it must overhang the side walls of the building, by an amount A E B on each side, if the framing is carried down to the same horizontal plane all the way around. Horizontal sections taken through the dome at intervals throughout its height, however, show smaller and smaller circles as they are taken nearer and nearer to the top of the dome. Some one of these sections will cut out from the dome a circle, which will appear in plan as though it were inscribed in the square formed by the walls of the building. Such a circle is shown at I J K L in Fig. 213. A dome built up with this circle as a base would not cover the corners of the building, so that the triangular spaces like A I L would be kept open. These triangular spaces, or rather the coverings over them, are called the pendentives. Fig. 214 shows in perspective the outline of four pendentives E D H, H C G, etc.

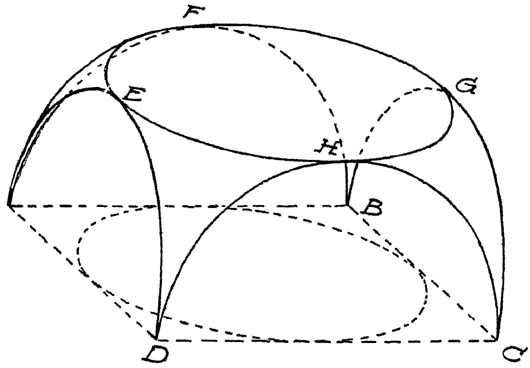


Fig 214 Pendentives

We have seen that a dome built up on the circumscribed circle as a base is too large, while a dome built upon the inscribed circle is too small and will not completely cover the building. To overcome this difficulty it is customary to erect a dome on the smaller or inscribed circle as a base, and to extend the ribs so as to fill up the corners and form a framework for the pendentives. This is shown in Fig. 215 which is a plan of the framework for a domical roof. The ribs will be of different lengths and will intersect the inside face of the wall at different heights, because as they are extended outward they must also be extended downward. Each one will be curved if the dome is spherical, and straight if the dome is conical. The upper ends of the ribs bear against the curb A leaving a circular opening for a lantern or cupola. The lower ends may be supported on a masonry wall, or may rest on curved wooden plates, as shown in Fig. 216. This is an elevation of a conical dome and shows the straight ribs *a b*, *c d*, etc.

Fig. 217 shows an elevation of a spherical dome which has curved ribs, *a b*, *c d*, etc., as shown. Each of these ribs must be bent or shaped to the segment of a circle, in order that their edges may lie in a spherical surface.

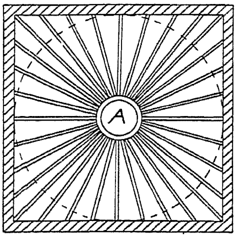


Fig. 215 Plan of Frame for Domical Roof

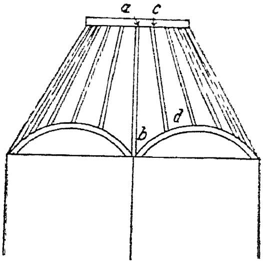


Fig. 216 Elevation of Conical Dome

If the design calls only for a domical *ceiling* and the exterior may be of some other form, then only the inside edges of the ribs need be dressed to correspond with a spherical or conical surface, in order that they may receive the lathing or furring, and the outside may be left rough and a false roof of any desired shape may be built. If the *exterior* must be of domical form while on the interior there is a suspended or false ceiling of some kind, then only the outside edges of the ribs must lie in the conical or spherical surface, so as to receive the roof boarding, while the inside edges may be left rough or shaped to any other form. If both the exterior and interior must be domical, then both the inside and outside edges of the ribs must be dressed so as to lie in the domical surface.

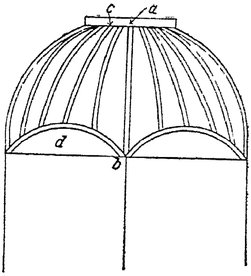


Fig. 217. Elevation of Spherical Dome.

Conical domes are very uncommon, but they are sometimes used. A conical dome is much easier to frame than a spherical dome because the ribs are straight. The shape of the curved plate which supports the lower ends of the ribs may be easily determined, since it must conform to the line of intersection between the conical or spherical surface of the dome, and the plane of the face of the wall.

Niches. Niches are of common occurrence in building work, especially in churches, halls and other important structures. Sometimes they are simply recesses in the wall with straight corners and a square head, but more often they are semicircular in form, with spherical heads in which case the framing becomes a matter of some difficulty. The framing of the wall for a semicircular niche is the easiest part of the work, since all the pieces may be straight, but for the framing of the head the ribs must be bent or shaped to conform to the surface of a sphere.

Fig. 218 shows in plan the way in which the vertical studding of the walls must be placed. The inside edges must lie in a cylindrical surface, and will receive the lathing and plastering. There must be a curved sole piece for them to rest upon at the bottom and a cap at the top. The cap is shown at A B in Fig. 219, which is an elevation of the *cradling* or framing for the niche. This figure shows how the ribs for the head of the niche must be bent. The ribs and vertical studs must be spaced not farther than twelve inches apart, center to center.

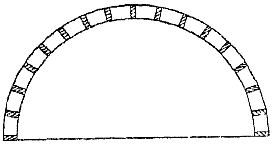


Fig 218 Plan of Vertical Studding for Niche.

The form of niche described above is the most common one for large niches intended to hold full size casts or other pieces of statuary, but smaller ones for holding busts and vases are quite common. These are often made in the form of a quarter sphere or some smaller segment of a sphere, with a flat base or floor and a spherical head, as is shown in section in Fig. 220. They are framed with curved ribs in the same way as described above, and finished with lathing and plastering.

Vaults and Groins. Although vaulted roofs are an outgrowth of masonry construction, and are almost always built of brick or stone, they are occasionally of timber, and in any case a timber centering must be built for them. A vault may be described as the surface generated by a curved line as the line moves through space, and in accordance with this definition there are vaults of all kinds, semicircular or *barrel* vaults, elliptical vaults, conical vaults, and many others.

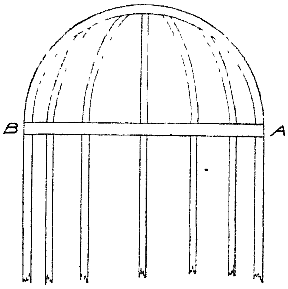


Fig 219 Elevation of Cradling for Niche.

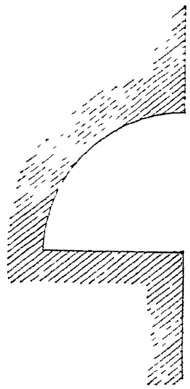


Fig 220 Section of Quarter-Sphere Niche

In Fig. 221 is shown in outline a simple semicircular or *barrel* vault, known as well by the name *cylindrical vault.* The point A where the straight vertical wall ends and the curved surface begins is called the *springing point.* The point B is the crown of the vault. The distance between the springing points on opposite sides of the vault is the *span*, and the vertical distance between the springing point and the crown B is the *rise*.

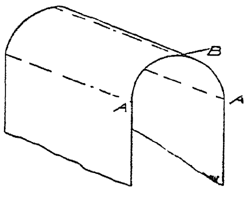


Fig 221 Barrel Vault

It may easily be seen how a barrel vault, or a vault of any kind, may be framed, with curved ribs spaced from one foot to eighteen inches apart on centers, and following the outline of a section of the vault. If the framework is intended to be permanent and to form the body of the vault itself, then the inner edges of the ribs must lie in the surface of the vault and must be covered with lathing and plastering. If only a centering is being built, on which it is intended that a masonry vault shall be supported temporarily, then the outer edges of the ribs must conform to the vaulted surface and must be covered with rough boarding to receive the masonry.

When two vaults intersect each other, as in the case of a main vault, and the vault over a transept, the ceiling at the place where vaults come together is said to be *groined*. The two vaults may be of the same height or of different heights. If they are of different heights the intersection is known as a *Welsh* groin. Welsh groins are of common occurrence in masonry construction, but in carpentry work the vaults are almost always made equal in height and often they are of equal span as well.

The framework for each vault is composed of ribs spaced comparatively close together, and resting on the side walls at the springing line. When, however, the two vaults intersect each other, the side walls must stop at the points where they meet, and a square or rectangular area is left which has no vertical walls around it. The covering for this area must be supported at the four corner points in which the side walls intersect. This is shown in plan in Fig. 222 where *a b c d* are the points of intersection of the walls of the vaults. The method of covering the area common to both vaults is also shown in the figure. Diagonal ribs *a d* and *c b* are put in place so as to span the distance from corner to corner and these form the basis for the rest of the framing. They must be bent to such a shape that they will coincide exactly with the line of intersection of the two vaulted services. The ribs which form the framing for the groined ceiling over the area are supported on the diagonal ribs as shown in the figure. They are arranged symmetrically with respect to the center, and are bent or shaped to the form of segments of circles or ellipses.

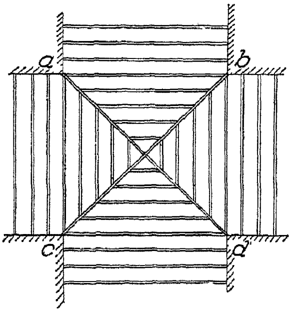


Fig 222 Plan of Cradling for Groined Ceiling.

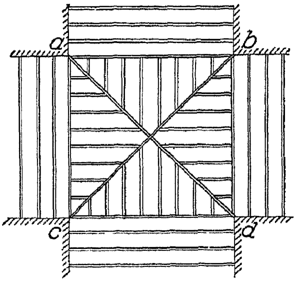


Fig. 223. Cradling for Groined Ceiling

Fig. 222 shows one method of forming the cradling for a groined ceiling, but there is another which is also in common use. This is shown in Fig. 223. There are four curved ribs *a b*, *b d*, *c d*, and *c a* which span the distances from corner to corner around the space to be covered. The diagonal ribs *a d* and *c b* are also employed as in the first method. Straight horizontal purlins are supported on these ribs, running parallel to the direction of the vaults, as shown in the figure. They are spaced about sixteen inches apart and form the framework for the ceiling.

The only difficult problem in connection with groined ceilings is to find the shape of the diagonal rib. This rib, as has been explained above, must coincide with the line of intersection of the vaults. The problem, then, is to find the true shape of the diagonal rib.

Let us consider the two vaults shown in plan in Fig. 224. They are not of the same span, but they will be of the same height if we wish to have a common groin and not a Welsh groin; so if one is semicircular the other must be elliptical. Elevations of ribs in each vault are shown at A and B and the diagonal ribs are shown in plan at *a c* and *b d*. It is easy to find the plan of these ribs because they must pass from corner to corner diagonally. To find the elevation we must use the same principle that was employed in finding the position of the valley rafter and the shape of the curved hip rafter for an ogee roof, namely, any line drawn in the roof or ceiling surface parallel to the plate or side walls, must be horizontal, and all points in it must be at the same elevation.

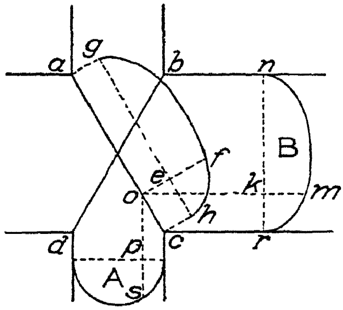
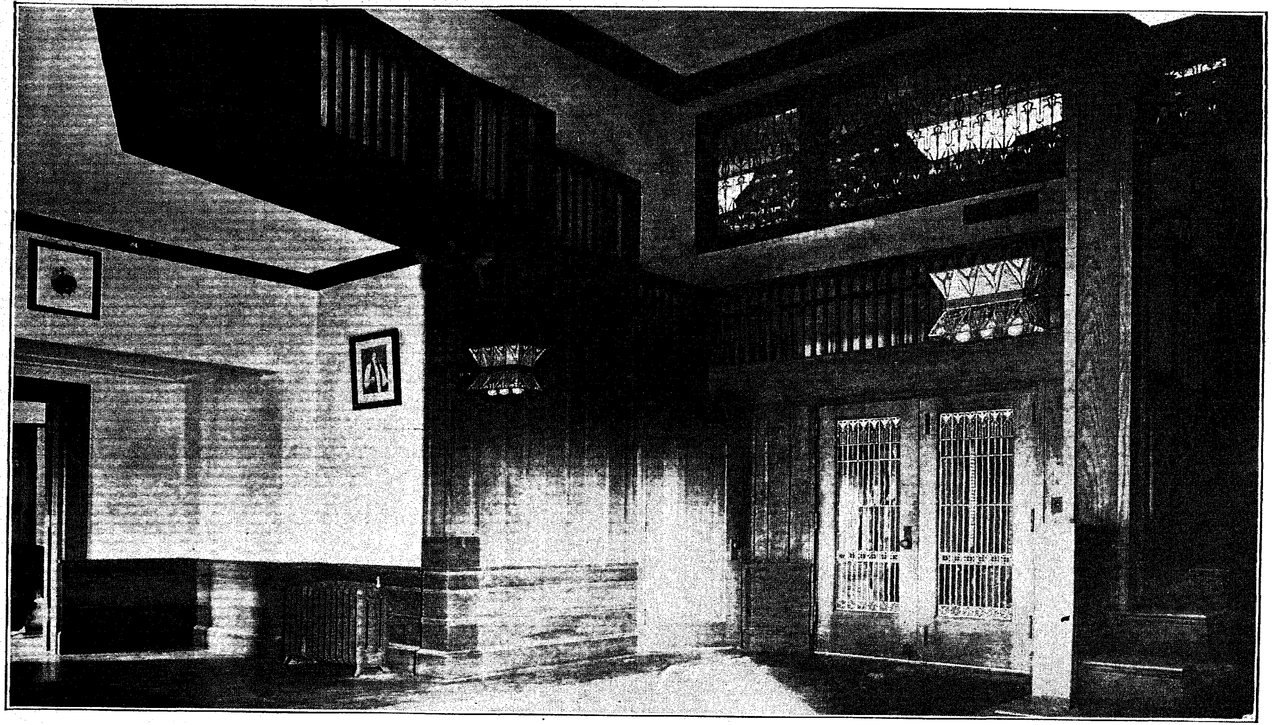


Fig. 224. Plan of Intersecting Vaults.

We start with the assumption that one of the vaults is semicircular, as shown in elevation at A, Fig. 224. Taking any line in the vaulted surface, shown in plan, as the line *s p o*, we produce it until it intersects the plan of the diagonal rib *a c* at the point *o*. This point must be the plan of one point in the line of intersection of the vaulted surfaces.

The elevation of the point *o* above the springing line of the vaults is shown by the distance *p s*, since the line *s p o* is exactly horizontal throughout. This distance is laid off at *e f* with the line *g e h* representing the horizontal plane which contains the springing lines of the vaults. The point *h* is the point from which the diagonal rib starts. The point *f*, as we have seen is another point in the curve, and we can by a similar process locate as many points as we need. This will enable us to draw the complete curve *g f h* of the line in which the vaults intersect, and to which the diagonal rib must conform.

By continuing the line from the point *o* at right angles to its former direction and parallel to the wall line we may obtain the point *k* which is a plan of one point in the surface of the elliptical vault. The elevation of this point also above the springing lines must be the same as for the point *s* and may be laid off, as shown at *k m*. By finding other points in a similar way the curve *n m r* of the elliptical vault may be readily determined.



ALPHA DELTA PHI CHAPTER HOUSE AT CORNELL UNIVERSITY, ITHACA, N. Y.

Dean & Dean, Architects, Chicago.

Front Hall Oak, Stained and Waxed; Plaster Stained and Waxed. The Stained Glass Window above the Stair-Landing is a Memorial to Ira A. Shaler.

STAIR-BUILDING

Introductory. In the following instructions in the art of Stair-building, it is the intention to adhere closely to the practical phases of the subject, and to present only such matter as will directly aid the student in acquiring a practical mastery of the art.

Stair-building, though one of the most important subjects connected with the art of building, is probably the subject least understood by designers and by workmen generally. In but few of the plans that leave the offices of Architects, are the stairs properly laid down; and many of the books that have been sent out for the purpose of giving instruction in the art of building, have this common defect—that the body of the stairs is laid down imperfectly, and therefore presents great difficulties in the construction of the rail.

The stairs are an important feature of a building. On entering a house they are usually the first object to meet the eye and claim the attention. If one sees an ugly staircase, it will, in a measure, condemn the whole house, for the first impression produced will hardly afterwards be totally eradicated by commendable features that may be noted elsewhere in the building. It is extremely important, therefore, that both designer and workman shall see that staircases are properly laid out.

Stairways should be commodious to ascend—inviting people, as it were, to go up. When winders are used, they should extend past the spring line of the cylinder, so as to give proper width at the narrow end (see Fig. 72) and bring the rail there as nearly as possible to the same pitch or slant as the rail over the square steps. When the hall is of sufficient width, the stairway should not be less than four feet wide, so that two people can conveniently pass each other thereon. The height of riser and width of tread are governed by the staircase, which is the space allowed for the stairway; but, as a general rule, the tread should not be less than nine inches wide, and the riser should not be over eight inches high. Seven-inch riser and eleven-inch tread will make an easy stepping stairway. If you increase the width of the tread, you must reduce the height of the riser. The tread and riser together should not be over eighteen inches, and not less than seventeen inches. These dimensions, however, cannot always be adhered to, as conditions will often compel a deviation from the rule; for instance, in large buildings, such as hotels, railway depots, or other public buildings, treads are often made 18 inches wide, having risers of from $2\frac{1}{2}$ inches to 5 inches depth.

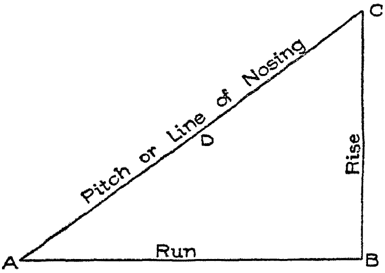


Fig 1. Illustrating Rise, Run, and Pitch.

Definitions. Before proceeding further with the subject, it is essential that the student make himself familiar with a few of the terms used in stair-building.

The term *rise and run* is often used, and indicates certain dimensions of the stairway. Fig. 1 will illustrate exactly what is meant; the line *A B* shows the *run*, or the length over the floor the stairs will occupy. From *B* to *C* is the rise, or the total height from *top* of lower floor to *top* of upper floor.* The line *D* is the *pitch* or *line of nosings*, showing the angle of inclination of the stairs. On the three lines shown—the *run*, the *rise*, and the *pitch*—depends the whole system of stair-building.

The *body* or *staircase* is the room or space in which the stairway is contained. This may be a space including the width and length of the stairway only, in which case it is called a *close stairway*, no rail or baluster being necessary. Or the stairway may be in a large apartment, such as a passage or hall, or even in a large room, openings being left in the upper floors so as to allow road room for persons on the stairway, and to furnish communication between the stairways and the different stories of the building. In such cases we have what are known as *open stairways*, from the fact that they are not closed on both sides, the steps showing their ends at one side, while on the other side they are generally placed against the wall.

Sometimes stairways are left open on both sides, a practice not

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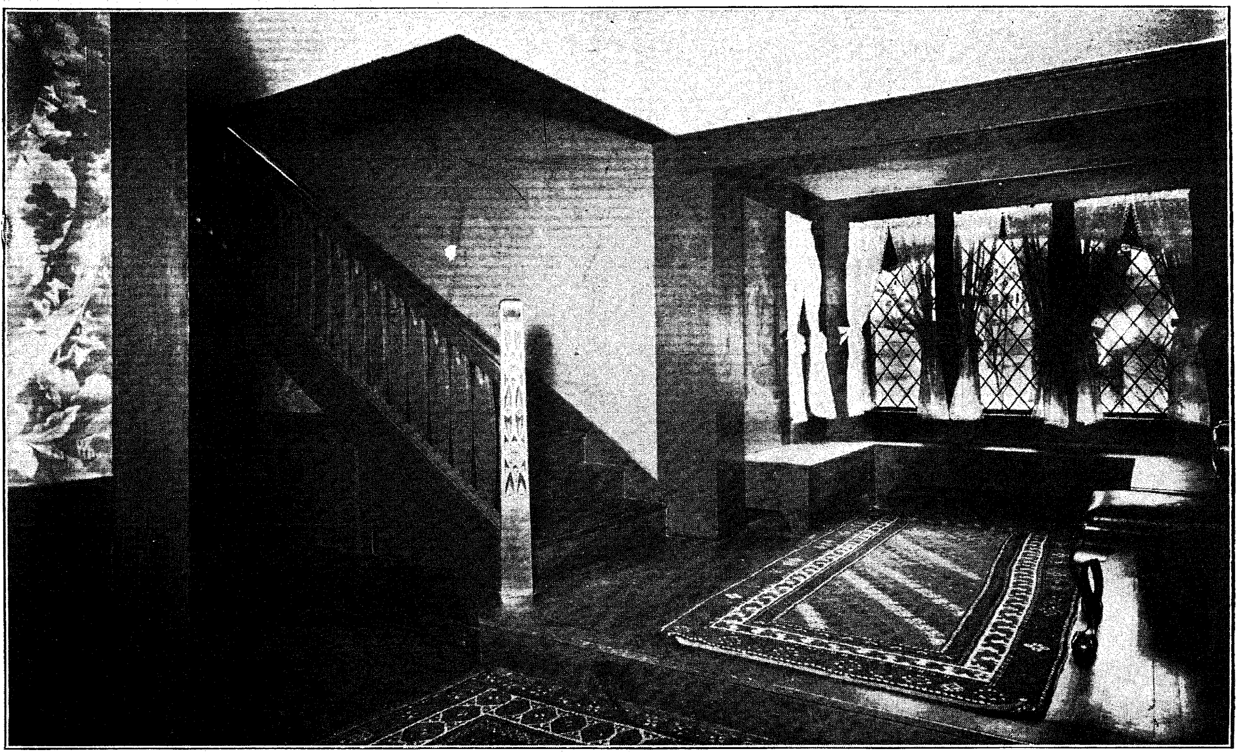
*NOTE.—The measure for the rise of a stairway must always be taken from the *top* of one floor to the *top* of the next.



STAIR HALL IN RESIDENCE OF MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York
For Plans, See Page 106.

uncommon in hotels, public halls, and steamships. When such stairs are employed, the openings in the upper floor should be well *trimmed* with joists or beams somewhat stronger than the ordinary joists used in the same floor, as will be explained further on.

Tread. This is the horizontal, upper surface of the step, upon which the foot is placed. In other words, it is the piece of material that forms the step, and is generally from 1¼ to 3 inches thick, and made of a width and length to suit the position for which it is intended. In small houses, the treads are usually made of ⅞-inch stuff.

Riser. This is the vertical height of the step. The riser is generally made of thinner stuff than the tread, and, as a rule, is not so heavy. Its duty is to connect the treads together, and to give the stairs strength and solidity.

Rise and Run. This term, as already explained, is used to indicate the horizontal and vertical dimensions of the stairway, the *rise* meaning the height from the top of the lower floor to the top of the second floor; and the *run* meaning the horizontal distance from the face of the first riser to the face of the last or top riser, or, in other words, the distance between the face of the first riser and the point where a plumb line from the face of the top riser would strike the floor. It is, in fact, simply the distance that the treads would make if put side by side and measured together—without, of course, taking in the nosings.

Suppose there are fifteen treads, each being 11 inches wide; this would make a run of 15 × 11 = 165 inches = 13 feet 9 inches. Sometimes this distance is called the *going* of the stair; this, however, is an English term, seldom used in America, and when used, refers as frequently to the length of the single tread as it does to the *run* of the stairway.

String-Board. This is the board forming the side of the stairway, connecting with, and supporting the ends of the steps. Where the steps are *housed*, or grooved into the board, it is known by the term *housed string;* and when it is cut through for the tread to rest upon, and is mitered to the riser, it is known by the term *cut and mitered string.* The dimensions of the lumber generally used for the purpose in practical work, are 9½ inches width and ⅞ inch thickness. In the first-class stairways the thickness is usually 1⅛ inches, for both front and wall strings.

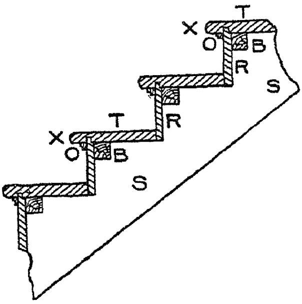


Fig 2 Common Method of Joining Risers and Treads

Fig. 2 shows the manner in which most stair-builders put their risers and treads together. *T* and *T* show the treads; *R* and *R*, the risers; *S* and *S*, the string; *O* and *O*, the cove mouldings under the nosings *X* and *X*. *B* and *B* show the blocks that hold the treads and risers together; these blocks should be from 4 to 6 inches long, and made of very dry wood; their section may be from 1 to 2 inches square. On a tread 3 feet long, three of these blocks should be used at about equal distances apart, putting the two outside ones about 6 inches from the strings. They are glued up tight into the angle. First warm the blocks; next coat two adjoining sides with good, strong glue; then put them in position, and nail them firmly to both tread and riser. It will be noticed that the riser has a lip on the upper edge, which enters into a groove in the tread. This lip is generally about $\frac{3}{8}$ inch long, and may be $\frac{3}{8}$ inch or $\frac{1}{2}$ inch in thickness. Care must be taken in getting out the risers, that they shall not be made too narrow, as allowance must be made for the lip.

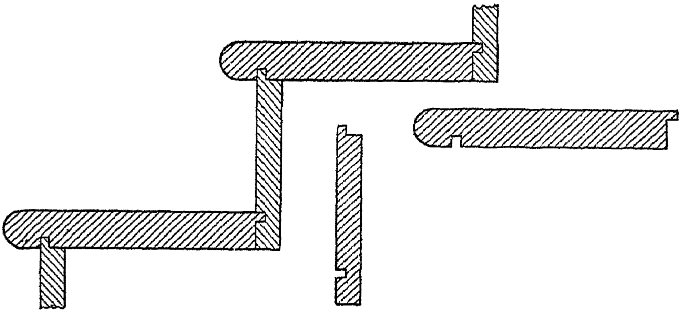


Fig 3 Vertical Section of Stair Steps.

Fig 4 End Section of Riser.

Fig 5 End Section of Tread

If the riser is a little too wide, this will do no harm, as the over-width may hang down below the tread; but it must be cut the exact width where it rests on the string. The treads must be made the exact width required, before they are grooved or have the nosing worked on the outer edge. The lip or tongue on the riser should fit snugly in the groove, and should *bottom*. By following these last instructions and seeing that the *blocks* are well glued in, a good solid job will be the result.

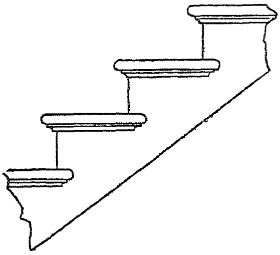


Fig 6 Side Elevation of Finished Steps with Return Nosings and Cove Moulding

Fig. 3 is a vertical section of stair steps in which the risers are shown tongued into the under side of the tread, as in Fig. 2, and also the tread tongued into the face of the riser. This last method is in general use throughout the country. The stair-builder, when he has steps of this kind to construct, needs to be very careful to secure the exact width for tread and riser, including the tongue on each. The usual method, in getting the parts prepared, is to make a pattern showing the end section of each. The millman, with these patterns to guide him, will be able to run the material through the machine without any danger of leaving it either too wide or too narrow; while, if he is left to himself without patterns, he is liable to make mistakes. These patterns are illustrated in Figs. 4 and 5 respectively, and, as shown, are merely end sections of riser and tread.

Fig. 6 is a side elevation of the steps as finished, with return nosings and cove moulding complete.

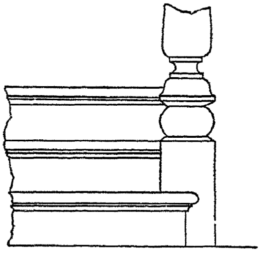


Fig 7 Front Elevation of Finished Steps.

A front elevation of the finished step is shown in Fig. 7, the nosing and riser returning against the base of the newel post. Often the newel post projects past the riser, in front; and when such is the case, the riser and nosing are cut square against the base of the newel.

Fig. 8 shows a portion of a cut and mitered string, which will give an excellent idea of the method of construction. The letter *O* shows the nosing, *F* the return nosing with a bracket terminating against it. These brackets are about $\frac{5}{16}$ inch thick, and are *planted* (nailed) on the string; the brackets miter with the ends of the risers; the ends of the brackets which miter with the risers, are to be the same height as the riser. The lower ends of two balusters are shown at *G G;* and the dovetails or mortises to receive these are shown at *E E.* Generally two balusters are placed on each tread, as shown; but there are sometimes instances in which three are used, while in others only one baluster is made use of.

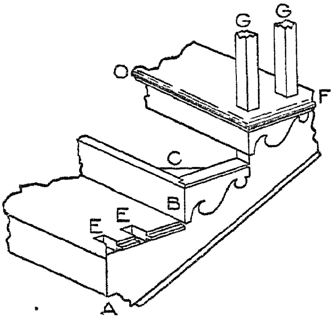


Fig. 8 Portion of a Cut and Mitered String, Showing Method of Constructing Stairs.

An end portion of a cut and mitered string is shown in Fig. 9, with part of the string taken away, showing the *carriage* — a rough piece of lumber to which the finished string is nailed or otherwise fastened. At *C* is shown the return nosing, and the manner in which the work is finished. A rough bracket is sometimes nailed on the carriage, as shown at *D*, to support the tread. The balusters are shown dovetailed into the ends of the treads, and are either glued or nailed in place, or both. On the lower edge of string, at *B*, is a return bead or moulding. It will be noticed that the rough carriage is *cut in* snugly against the floor joist.

Fig. 10 is a plan of the portion of a stairway shown in Fig. 9. Here the position of the string, bracket, riser, and tread can be seen. At the lower step is shown how to miter the riser to the string; and at the second step is shown how to miter it to the bracket.

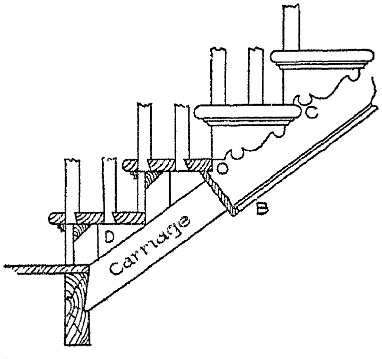


Fig. 9 End Portion of Cut and Mitered String, with Part Removed to Show Carriage

Fig. 11 shows a quick method of marking the ends of the treads for the dovetails for balusters. The templet *A* is made of some thin material, preferably zinc or hardwood. The dovetails are outlined as shown, and the intervening portions of the material are cut away, leaving the dovetail portions solid. The templet is then nailed or screwed to a gauge-block *E*, when the whole is ready for use. The method of using is clearly indicated in the illustration.

Strings. There are two main kinds of stair strings—*wall strings* and *cut strings*. These are divided, again, under other names, as *housed* strings, *notched* strings, *staved* strings, and *rough* strings.

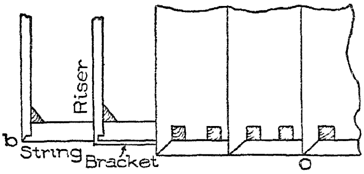


Fig. 10. Plan of Portion of Stair.

Wall strings are the supporters of the ends of the treads and risers that are against the wall; these strings may be at both ends of the treads and risers, or they may be at one end only. They may be *housed* (grooved) or left solid. When housed, the treads and risers are keyed into them, and glued and blocked. When left solid, they have a rough string or carriage spiked or screwed to them, to lend additional support to the ends of risers and treads. Stairs made after this fashion are generally of a rough, strong kind, and are especially adapted for use in factories, shops, and warehouses, where strength and rigidity are of more importance than mere external appearance.

Open strings are outside strings or supports, and are cut to the proper angles for receiving the ends of the treads and risers. It is over a string of this sort that the rail and balusters range; it is also on such a string that al nosings return; hence, in some localities, an open string is known as a *return string*.

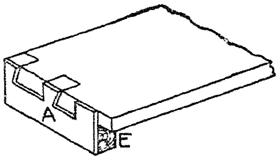


Fig 11 Templet Used to Mark Dovetail Cuts for Balusters.

Housed strings are those that have grooves cut in them to receive the ends of treads and risers. As a general thing, wall strings are housed. The housings are made from $\frac{5}{8}$ to $\frac{3}{4}$ inch deep, and the lines at top of tread and face of riser are made to correspond with the lines of riser and tread when in position. The back lines of the housings are so located that a taper wedge may be driven in so as to force the tread and riser close to the face shoulders, thus making a tight joint.

Rough strings are cut from undressed plank, and are used for strengthening the stairs. Sometimes a combination of rough-cut strings is used for circular or geometrical stairs, and, when framed together, forms the support or carriage of the stairs.

Staved strings are built-up strings, and are composed of narrow pieces glued, nailed, or bolted together so as to form a portion of a cylinder. These are sometimes used for circular stairs, though in ordinary practice the circular part of a string is a part of the main string bent around a cylinder to give it the right curve.

Notched strings are strings that carry only treads. They are generally somewhat narrower than the treads, and are housed across their entire width. A sample of this kind of string is the side of a common step-ladder. Strings of this sort are used chiefly in cellars, or for steps intended for similar purposes.

Setting Out Stairs. In setting out stairs, the first thing to do is to ascertain the locations of the first and last risers, with the height of the story wherein the stair is to be placed. These points should be marked out, and the distance between them divided off equally, giving the number of steps or treads required. Suppose we have between these two points 15 feet, or 180 inches. If we make our treads 10 inches wide, we shall have 18 treads. It must be remembered that *the number of risers is always one more than the number of treads,* so that in the case before us there will be 19 risers.

The height of the story is next to be exactly determined, being taken on a rod. Then, assuming a height of riser suitable to the place, we ascertain, by division, how often this height of riser is contained in the height of the story; the quotient, if there is no remainder, will be the number of risers in the story. Should there be a remainder on the first division, the operation is reversed, the number of inches in the height being made the dividend, and the before-found quotient, the divisor. The resulting quotient will indicate an amount to be added to the former assumed height of riser for a new trial height. The remainder will now be less than in the former division; and if necessary, the operation of reduction by division is repeated, until the height of the riser is obtained to the thirty-second part of an inch. These heights are then set off on the story rod as exactly as possible.

The *story rod* is simply a dressed or planed pole, cut to a length exactly corresponding to the height from the top of the lower floor to the top of the next floor. Let us suppose this height to be 11 feet 1 inch, or 133 inches. Now, we have 19 risers to place in this space, to enable us to get upstairs; therefore, if we divide 133 by 19, we get 7 without any remainder. Seven inches will therefore be the width or height of the riser Without figuring this out, the workman may find the exact width of the riser by dividing his story rod, by means of pointers, into 19 equal parts, any one part being the proper width. It may be well, at this point, to remember that *the first riser must always be narrower than the others*, because the thickness of the first tread must be taken off.

The width of treads may also be found without figuring, by pointing off the *run* of the stairs into the required number of parts; though, where the student is qualified, it is always better to obtain the width, both of treads and of risers, by the simple arithmetical rules.

Having determined the width of treads and risers, a *pitch-board* should be formed, showing the angle of inclination. This is done by cutting a piece of thin board or metal in the shape of a right-angled triangle, with its base exactly equal to the run of the step, and its perpendicular equal to the height of the riser. It is a general maxim, that the greater the breadth of a step or tread, the less should be the height of the riser; and, conversely, the less the breadth of a step, the greater should be the height of the riser. The proper relative dimensions of treads and risers may be illustrated graphically, as in Fig. 12.

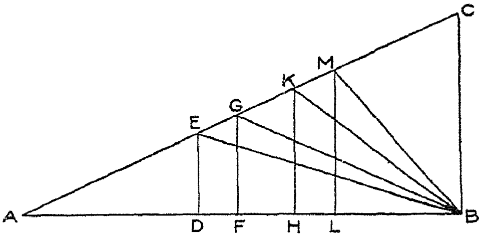


Fig 12 Graphic Illustration of Proportional Dimensions of Treads and Risers.

In the right-angle triangle *A B C*, make *A B* equal to 24 inches, and *B C* equal to 11 inches—the standard proportion. Now, to find the riser corresponding to a given width of tread, from *B*, set off on *A B* the width of the tread, as *B D;* and from *D*, erect a perpendicular *D E*, meeting the hypotenuse in *E;* then *D E* is the height of the riser; and if we join *B* and *E*, the angle *D B E* is the angle of inclination, showing the slope of the ascent. In like manner, where *B F* is the width of the tread, *F G* is the riser, and *B G* the slope of the stair. A width of tread *B H* gives a riser of the height of *H K;* and a width of tread equal to *B L* gives a riser equal to *L M.*

In the opinion of many builders, however, a better scheme of proportions for treads and risers is obtained by the following method:

Set down two sets of numbers, each in arithmetical progression—the first set showing widths of tread, increasing by inches; the other showing heights of riser, decreasing by half-inches.

Treads, Inches	Risers, Inches
5	9
6	8½
7	8
8	7½
9	7
10	6½
11	6
12	5½
13	5
14	4½
15	4
16	3½
17	3
18	2½

It will readily be seen that each pair of treads and risers thus obtained is suitably proportioned as to dimensions.

It is seldom, however, that the proportions of treads and risers are entirely a matter of choice. The space allotted to the stairs usually determines this proportion; but the above will be found a useful standard, to which it is desirable to approximate.

In the better class of buildings, the number of steps is considered in the plan, which it is the business of the Architect to arrange; and in such cases, the height of the story rod is simply divided into the number required.

Pitch-Board. It will now be in order to describe a pitch-board and the manner of using it; no stairs can be properly built without the use of a pitch-board in some form or other. Properly speaking, a pitch-board, as already explained, is a thin piece of material, generally pine or sheet metal, and is a right-angled triangle in outline. One of its sides is made the exact height of the rise; at right angles with this line of rise, the exact width of the tread is measured off; and the material is cut along the hypotenuse of the right-angled triangle thus formed.

The simplest method of making a pitch-board is by using a steel square, which, of course, every carpenter in this country is supposed to possess. By means of this invaluable tool, also, a stair string can be laid out, the square being applied to the string as shown in Fig. 13. In the instance here illustrated, the square shows 10 inches for the tread and 7 inches for the rise.

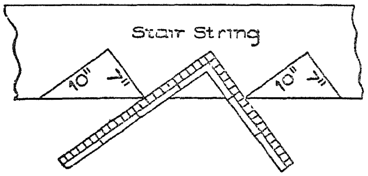


Fig. 13 Steel Square Used as a Pitch-Board in Laying Out Stair String

To cut a pitch-board, after the tread and rise have been determined, proceed as follows: Take a piece of thin, clear material, and lay the square on the face edge, as shown in Fig. 13. Mark out the pitch-board with a sharp knife; then cut out with a fine saw, and dress to the knife marks; nail a piece on the largest edge of the pitch-board for a gauge or fence, and it is ready for use.

Fig. 14 shows the pitch-board pure and simple; it may be half an inch thick, or, if of hardwood, may be from a quarter-inch to a half-inch thick.

Fig. 15 shows the pitch-board after the gauge or fence is nailed on. This fence or gauge may be about $1\frac{1}{2}$ inches wide and from $\frac{3}{8}$ to $\frac{3}{4}$ inch thick .

Fig. 16 shows a sectional view of the pitch-board with a fence nailed on.

In Fig. 17 the manner of applying the pitch-board is shown. *R R R* is the string, and the line *A* shows the jointed or straight edge of the string. The pitch-board *P* is shown in position, the line $8\frac{1}{3}$ represents the step or tread, and the line $7\frac{3}{4}$ shows the line of the riser. These two lines are of course at right angles, or, as the carpenter would say, they are *square*. This string shows four complete cuts, and part of a fifth cut for treads, and five complete cuts for risers. The bottom of the string at *W* is cut off at the line of the floor on which it is supposed to rest. The line *C* is the line of the first riser. This riser is cut lower

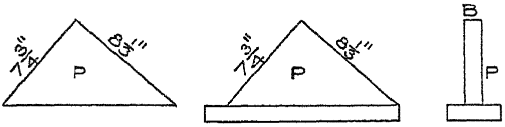


Fig 14 Fig 15. Fig. 16

Showing How a Pitch-Board is Made
Fig. 15 shows gauge fastened to long edge. Fig 16 is a sectional elevation of completed board

than any of the other risers, because, as above explained, the thickness of the first tread is always taken off it; thus, if the tread is 1½ inches thick, the riser in this case would only require to be 6¼ inches wide, as 7¾ − 1½ = 6¼

The string must be cut so that the line at *W* will be only 6¼ inches from the line at 8⅓, and these two lines must be parallel. The first riser and tread having been satisfactorily dealt with, the rest can easily be marked off by simply sliding the pitch-board along the line *A* until the outer end of the line 8⅓ on the pitch-board strikes the outer end of the line 7¾ on the string, when another tread and another riser are to be marked off. The remaining risers and treads are marked off in the same manner.

Sometimes there may be a little difficulty at the top of the stairs, in fitting the string to the trimmer or joists; but, as it is necessary first to become expert with the pitch-board, the method of trimming the well or attaching the cylinder to the string will be left until other matters have been discussed.

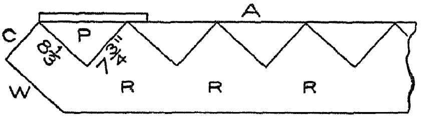


Fig 17 Showing Method of Using Pitch-Board.

Fig. 18 shows a portion of the stairs in position. *S* and *S* show the strings, which in this case are cut square; that is, the part of the string to which the riser is joined is cut square across, and the butt or end wood of the riser is seen. In this case, also, the end of the tread is cut square off, and flush with the string and riser. Both strings in this instance are open strings. Usually, in stairs of this kind, the ends of the treads are rounded off similarly to the front of the tread, and the ends project over the strings the same distance that the front edge projects over the riser. If a moulding or *cove* is used under the nosing in front, it should be carried round on the string to the back edge of the tread and cut off square, for in this case the back edge of the tread will be square. A riser is shown at *R*, and it will be noticed that it runs down behind the tread on the back edge, and is either nailed or screwed to the tread. This is the American practice, though in England the riser usually rests on the tread, which extends clear back to string as shown at the top tread in the diagram. It is much better, however, for general purposes, that the riser go behind the tread, as this tends to make the whole stairway much stronger.

Housed strings are those which carry the treads and risers without their ends being seen. In an open stair, the wall string only is housed, the other ends of the treads and risers resting on a cut string, and the nosings and mouldings being returned as before described.

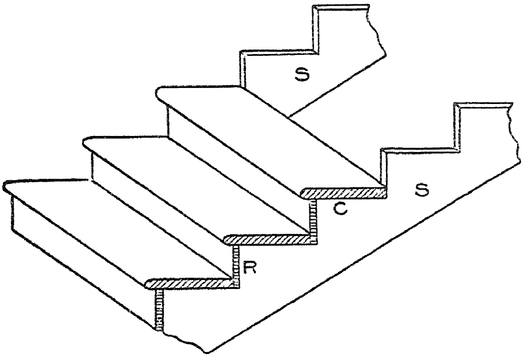


Fig 18 Portion of Stair in Position

The manner of housing is shown in Fig. 19, in which the treads *T T* and the risers *R R* are shown in position, secured in place respectively by means of wedges *X X* and *F F*, which should be well covered with good glue before insertion in the groove. The housings are generally made from ½ to ⅝ inch deep, space for the wedge being cut to suit.

In some closed stairs in which there is a housed string between the newels, the string is double-tenoned into the shanks of both newels, as shown in Fig. 20. The string in this example is made 12¾ inches wide, which is a very good width for a string of this kind; but the thickness should never be less than 1½ inches. The upper newel is made about 5 feet 4 inches long from drop to top of cap. These strings are generally capped with a subrail of some kind, on which the baluster, if any, is cut-mitered in. Generally a groove, the width of the square of the balusters, is worked on the top of the subrail, and the balusters are worked out to fit into this groove; then pieces of this material, made the width of the groove and a little thicker than the groove is deep, are cut so as to fit in snugly between the ends of the balusters resting in the groove. This makes a solid job; and the pieces between the balusters may be made

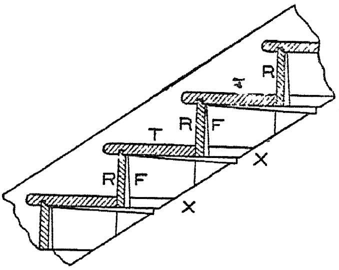


Fig 19 Showing Method of Housing Treads and Risers

of any shape on top, either beveled, rounded, or moulded, in which case much is added to the appearance of the stairs.

Fig. 21 exhibits the method of attaching the rail and string to the bottom newel. The dotted lines indicate the form of the tenons cut to fit the mortises made in the newel to receive them.

Fig. 22 shows how the string fits against the newel at the top; also the trimmer *E*, to which the newel post is fastened. The string in this case is tenoned into the upper newel post the same way as into the lower one.

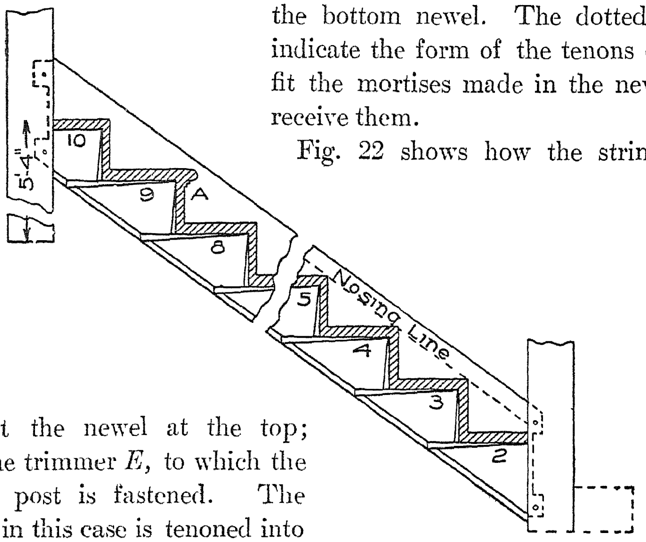


Fig 20 Showing Method of Connecting Housed String to Newels.

The open string shown in Fig. 23 is a portion of a finished string, showing nosings and cove returned and finishing against the face of the string. Along the lower edge of the string is shown a bead or moulding, where the plaster is finished.

A portion of a stair of the better class is shown in Fig. 24. This is an open, bracketed string, with returned nosings and coves and scroll brackets. These brackets are made about $\frac{3}{8}$ inch thick, and may be in any desirable pattern. The end next the riser should be mitered to suit; this will require the riser to be $\frac{3}{8}$ inch longer than the face of the string. The upper part of the bracket should run under the cove moulding; and the tread should project over the string the full $\frac{3}{8}$ inch, so as to cover the

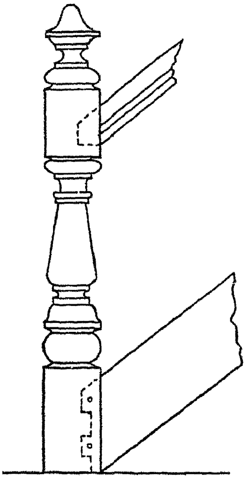


Fig 21. Method of Connecting Rail and String to Bottom Newel.

bracket and make the face even for the nosing and the cove moulding to fit snugly against the end of the tread and the face of the bracket. Great care must be taken about this point, or endless trouble will follow. In a bracketed stair of this kind, care must be taken in placing the newel posts, and provision must be made for the extra ⅜ inch due to the bracket. The newel post must be set out from the string ⅜ inch, and it will then align with the baluster.

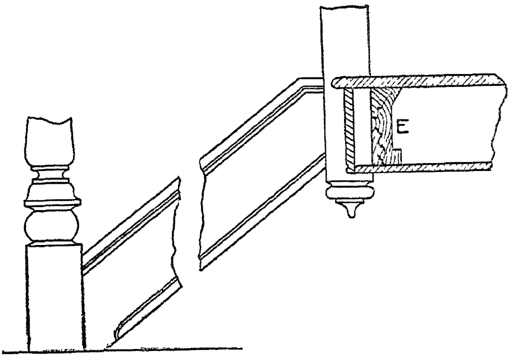


Fig. 22. Connections of String and Trimmer at Upper Newel Post.

We have now described several methods of dealing with strings; but there are still a few other points connected with these members, both housed and open, that it will be necessary to explain, before the young workman can proceed to build a fair flight of stairs. The connection of the wall string to the lower and upper floors, and the manner of affixing the outer or cut string to the upper joist and to the newel, are matters that must not be overlooked. It is the intention to show how these things are accomplished, and how the stairs are made strong by the addition of rough strings or bearing carriages.

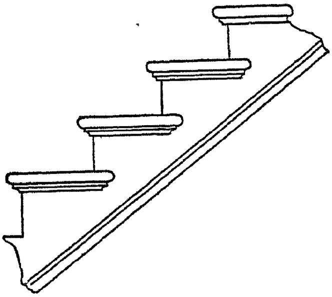


Fig. 23. Portion of Finished String, Showing Returned Nosings and Coves, also Bead Moulding.

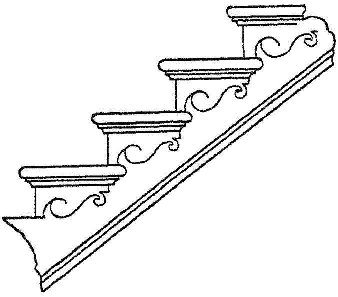


Fig. 24 Portion of Open, Bracketed String Stair, with Returned Nosings and Coves, Scroll Brackets, and Bead Moulding

Fig 25 gives a side view of part of a stair of the better class, with one open, cut and mitered string. In Fig. 26, a plan of this same stairway, *W S* shows the wall string; *R S*, the rough string, placed there to give the structure strength; and *O S*, the outer or cut and mitered string. At *A A* the ends of the risers are shown, and it will be noticed that they are mitered against a vertical or riser line of the string, thus preventing the end of the riser from being seen. The other end of the riser is in the housing in the wall string. The outer end of the tread is also mitered at the nosing, and a piece of material made or worked like the nosing is mitered against or returned at the end of the tread. The end of this returned piece is again returned on itself back to the string, as shown at *N* in Fig. 25. The moulding, which is ⅝-inch cove in this case, is also returned on itself back to the string.

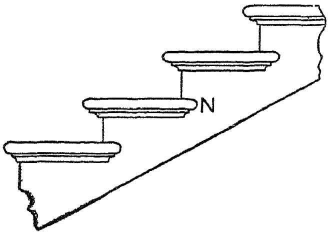


Fig. 25 Side Elevation of Part of Stair with Open, Cut and Mitered String.

The mortises shown at *B B B B* (Fig. 26), are for the balusters. It is always the proper thing to saw the ends of the treads ready for the balusters before the treads are attached to the string; then, when the time arrives to put up the rail, the back ends of the mortises can be cut out, when the treads will be ready to receive the balusters. The mortises are dovetailed, and, of course, the tenons on the balusters must be made to suit. The treads are finished on the bench; and the return nosings are fitted to them and tacked on, so that they may be taken off to insert the balusters when the rail is being put in position.

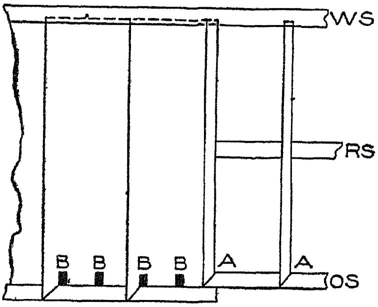


Fig 26. Plan of Part of Stair Shown in Fig. 25.

Fig. 27 shows the manner in which a wall string is finished at the foot of the stairs. *S* shows the string, with moulding wrought on the upper edge. This moulding may be a simple ogee, or may consist of a number of members; or it may be only a bead; or, again, the edge of the string may be left quite plain, this will be regulated in great measure by the style of finish in the hall or other part of the house in which the stairs are placed. *B* shows a portion of a baseboard, the top edge of which has the same finish as the top edge of the string. *B* and *A* together show the junction of the string and base. *F F* show blocks glued in the angles of the steps to make them firm and solid.

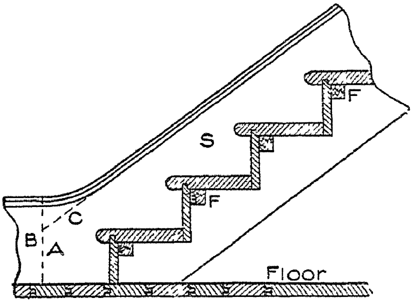


Fig. 27. Showing How Wall String is Finished at Foot of Stair

Fig. 28 shows the manner in which the wall string *S* is finished at the top of the stairs. It will be noticed that the moulding is worked round the ease-off at *A* to suit the width of the base at *B*. The string is cut to fit the floor and to butt against the joist. The plaster line under the stairs and on the ceiling, is also shown.

Fig. 29 shows a cut or open string at the foot of a stairway, and the manner of dealing with it at its junction with the newel post *K*. The point of the string should be mortised into the newel 2 inches, 3 inches, or 4 inches, as shown by the dotted lines; and the mortise in the newel should be cut near the center, so that the center of the baluster will be directly opposite the central line of the newel post. The proper way to manage this, is to mark the central line of the baluster on the tread, and then make this line correspond with the central line of the newel post. By careful attention to this point, much trouble will be avoided where a turned cap is used to receive the lower part of the rail.

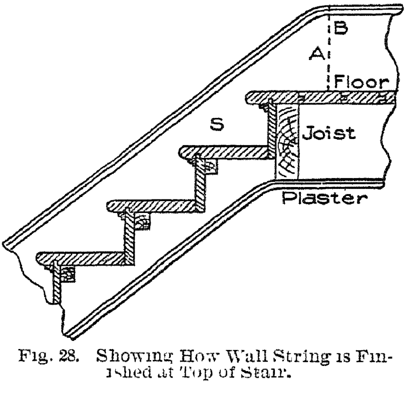


Fig. 28. Showing How Wall String is Finished at Top of Stair.

The lower riser in a stair of this kind will be somewhat shorter than the ones above it, as it must be cut to fit between the newel and the wall string A portion of the tread, as well as of the riser, will also butt against the newel, as shown at *W*.

If there is no spandrel or wall under the open string, it may run down to the floor as shown by the dotted line at *O*. The piece *O* is glued to the string, and the moulding is worked on the curve. If there is a wall under the string *S*, then the base *B*, shown by the dotted lines, will finish against the string, and it should have a moulding on its upper edge, the same as that on the lower edge of the string, if any, this moulding being mitered into the one on the string. When there is a base, the piece *O* is of course dispensed with.

The square of the newel should run down by the side of a joist as shown, and should be firmly secured to the joist either by spiking or by some other suitable device. If the joist runs the other way, try to get the newel post against it, if possible, either by furring out the joist or by cutting a portion off the thickness of the newel. The solidity of a stair and the firmness of the rail, depend very much upon the rigidity of the newel post. The above suggestions are applicable where great strength is required, as in public buildings. In ordinary work, the usual method is to let the newel rest on the floor.

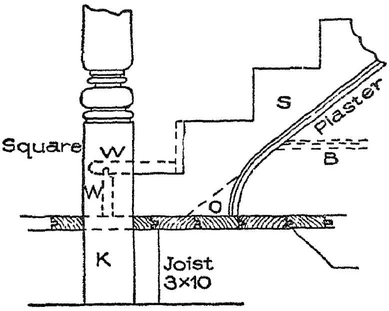
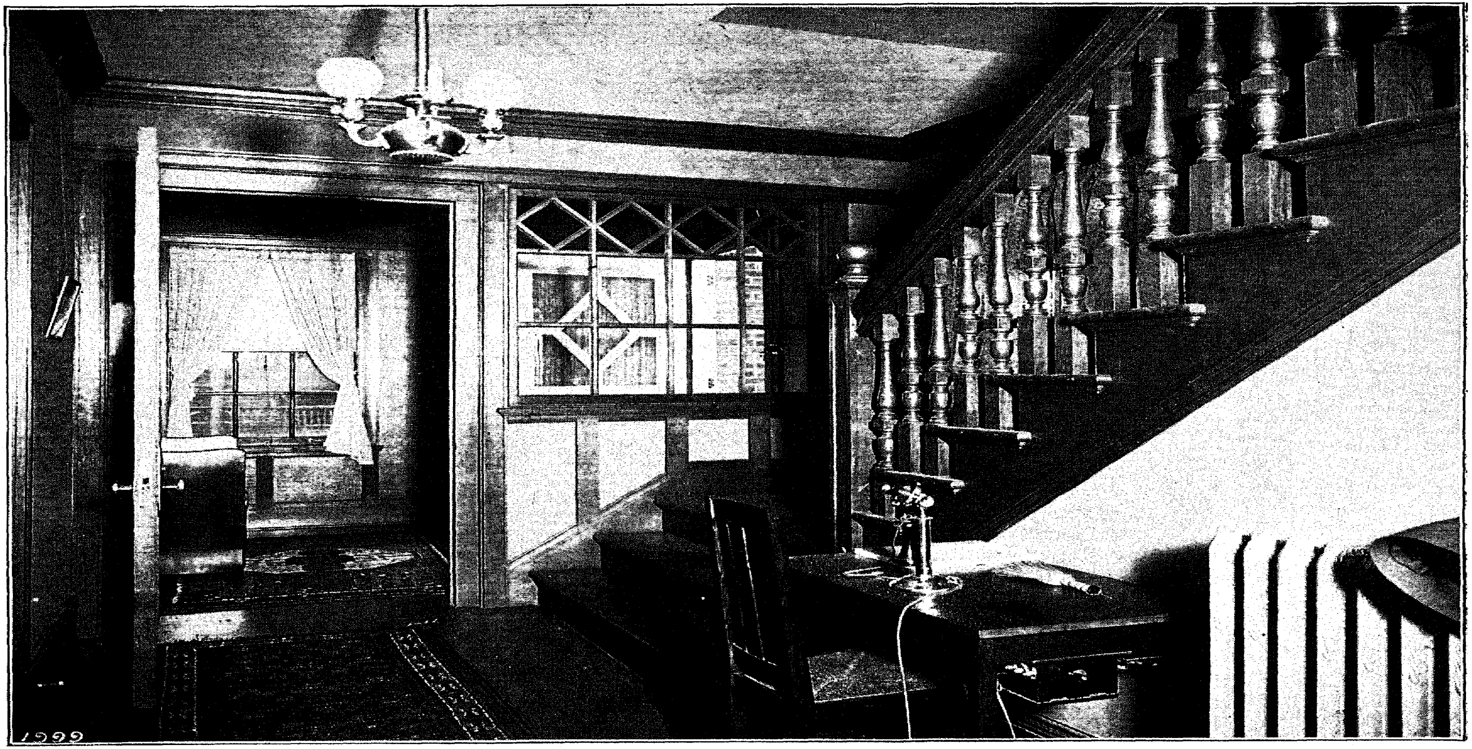


Fig. 29. Showing How a Cut or Open String is Finished at Foot of Stair.

Fig. 30 shows how the cut string is finished at the top of the stairs. This illustration requires no explanation after the instructions already given.

Thus far, stairs having a newel only at the bottom have been dealt with. There are, however, many modifications of straight and return stairs which have from two to four or six newels. In such cases, the methods of treating strings at their finishing points must necessarily be somewhat different from those described; but the general principles, as shown and explained, will still hold good.

Well-Hole. Before proceeding to describe and illustrate neweled stairs, it will be proper to say something about the *well-hole*, or the



STAIR HALL IN RESIDENCE AT KENOSHA, WIS.
Pond & Pond, Architects, Chicago, Ill.
For Plan and Exterior, See Vol. III, Page 314.

opening through the floors, through which the traveler on the stairs ascends or descends from one floor to another.

Fig. 31 shows a well-hole, and the manner of trimming it. In this instance the stairs are placed against the wall; but this is not necessary in all cases, as the well-hole may be placed in any part of the building.

The arrangement of the trimming varies according as the joists are at right angles to, or are parallel to, the wall against which the stairs are built. In the former case (Fig. 31, *A*) the joists are cut short and tusk-tenoned into the heavy trimmer *T T*, as shown in the cut. This trimmer is again tusk-tenoned into two heavy joists *T J* and *T J*, which form the ends of the well-hole. These heavy joists are called *trimming joists;* and, as they have to carry a much heavier load than other joists on the same floor, they are made much heavier. Sometimes two or three joists are placed together, side by side, being bolted or spiked together to give them the desired unity and strength. In constructions requiring great strength, the tail and header joists of a well-hole are suspended on iron brackets.

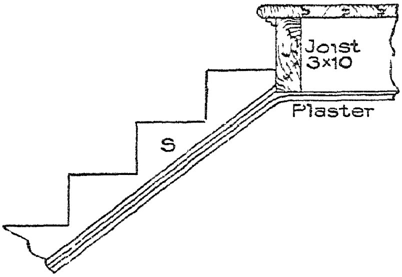


Fig. 30. Showing How a Cut or Open String is Finished at Top of Stair.

If the opening runs parallel with the joists (Fig. 31, *B*), the timber forming the side of the well-hole should be left a little heavier than the other joists, as it will have to carry short trimmers (*T J* and *T J*) and the joists running into them. The method here shown is more particularly adapted to brick buildings, but there is no reason why the same system may not be applied to frame buildings.

Usually in cheap, frame buildings, the trimmers *T T* are spiked against the ends of the joists, and the ends of the trimmers are supported by being spiked to the trimming joists *T J*, *T J*. This is not very workmanlike or very secure, and should not be done, as it is not nearly so strong or durable as the old method of framing the joists and trimmers together.

Fig. 32 shows a stair with three newels and a platform. In this example, the first tread (No. 1) stands forward of the newel post two-thirds of its width. This is not necessary in every case, but it is sometimes done to suit conditions in the hallway. The second newel is placed at the twelfth riser, and supports the upper end of the first cut string and the lower end of the second cut string. The platform (12) is supported by joists which are framed into the wall and are fastened against a trimmer running from the wall to the newel along the line 12. This is the case only when the second newel runs down to the floor.

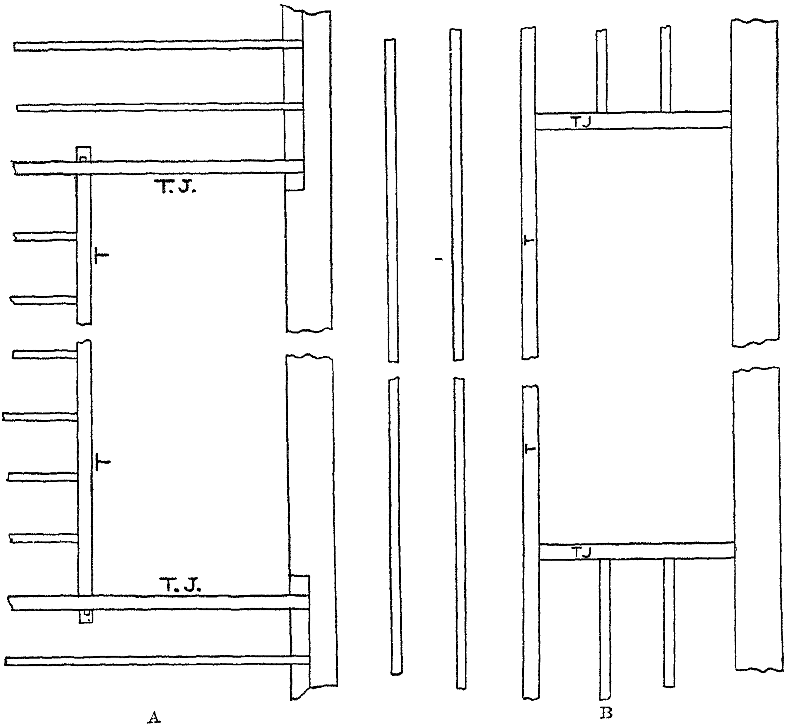


Fig. 31. Showing Ways of Trimming Well-Hole when Joists Run in Different Directions.

If the second newel does not run to the floor, the framework supporting the platform will need to be built on studding. The third newel stands at the top of the stairs, and is fastened to the joists of the second floor, or to the trimmer, somewhat after the manner of fastening shown in Fig. 29. In this example, the stairs have 16 risers and 15 treads, the platform or landing (12) making one tread. The figure 16 shows the floor in the second story.

This style of stair will require a well-hole in shape about as shown in the plan; and where strength is required, the newel at the top should run from floor to floor, and act as a support to the joists and trimmers on which the second floor is laid.

Perhaps the best way for a beginner to go about building a stairway of this type, will be to lay out the work on the lower floor in the exact place where the stairs are to be erected, making everything full size. There will be no difficulty in doing this; and if the positions of the first riser and the three newel posts are accurately defined, the building of the stairs will be an easy matter. Plumb lines can be raised from the lines on the floor, and the positions of the platform and each riser thus easily determined. Not only is it best to line out on the floor all stairs having more than one newel; but in constructing any kind of stair it will perhaps be safest for a beginner to lay out in exact position on the floor the points over which the treads and risers will stand. By adopting this rule, and seeing that the strings, risers, and treads correspond exactly with the lines on the floor, many cases of annoyance will be avoided. Many expert stair-builders, in fact, adopt this method in their practice, laying out all stairs on the floor, including even the carriage strings, and they cut out all the material from the lines obtained on the floor. By following this method, one can see exactly the requirements in each particular case, and can rectify any error without destroying valuable material.

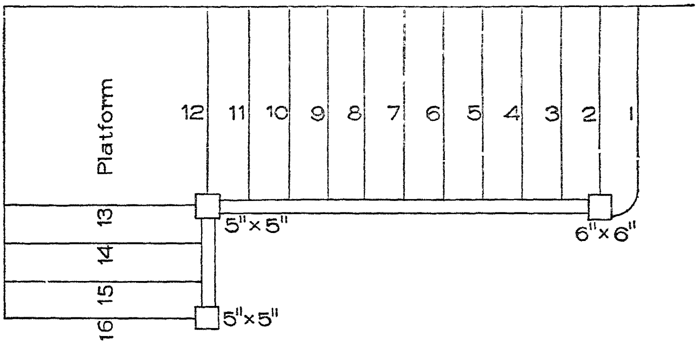


Fig. 32. Stair with Three Newels and a Platform.

Laying Out. In order to afford the student a clear idea of what is meant by *laying out* on the floor, an example of a simple close-string stair is given. In Fig. 33, the letter *F* shows the floor line; *L* is the landing or platform; and *W* is the wall line. The stair is to be 4 feet wide over strings; the landing, 4 feet wide; the height from floor to landing, 7 feet; and the run from start to finish of the stair, 8 feet 8½ inches.

The first thing to determine is the dimensions of the treads and risers. The wider the tread, the lower must be the riser, as stated before. No definite dimensions for treads and risers can be given, as the steps have to be arranged to meet the various difficulties that may occur in the working out of the construction; but a common rule is this: Make the width of the tread, plus twice the rise, equal to 24 inches. This will give, for an 8-inch tread, an 8-inch rise; for a 9-inch tread, a 7½-inch rise; for a 10-inch tread, a 7-inch rise, and so on. Having the height (7 feet) and the run of the flight (8 feet 8½ inches), take a rod about one inch square, and mark on it the height from floor to landing (7 feet), and the length of the going or run of the flight (8 feet 8½ inches). Consider now what are the dimensions which can be given to the treads and risers, remembering that there will be one more riser than the number of treads. Mark off on the rod the landing, forming the last tread. If twelve risers are desired, divide the height (namely, 7 feet) by 12, which gives 7 inches as the rise of each step. Then divide the run (namely, 8 feet 8½ inches) by 11, and the width of the tread is found to be 9½ inches.

Great care must be taken in making the pitch-board for marking off the treads and risers on the string. The pitch-board may be made from dry hardwood about ⅜ inch thick. One end and one side must be perfectly square to each other; on the one, the width of the tread is set off, and on the other the height of the riser. Connect the two points thus obtained, and saw the wood on this line. The addition of a gauge-piece along the longest side of the triangular piece, completes the pitch-board, as was illustrated in Fig. 15.

The length of the wall and outer string can be ascertained by means of the pitch-board. One side and one edge of the wall string must be squared; but the outer string must be trued all round. On the strings, mark the positions of the treads and risers by using the pitch-board as already explained (Fig. 17). Strings are usually made 11 inches wide, but may be made 12½ inches wide if necessary for strength

After the widths of risers and treads have been determined, and the string is ready to lay out, apply the pitch-board, marking the first riser about 9 inches from the end; and number each step in succession. The thickness of the treads and risers can be drawn by using thin strips of hardwood made the width of the housing required. Now allow for the wedges under the treads and behind the risers, and thus find the exact width of the housing, which should be about ⅝ inch

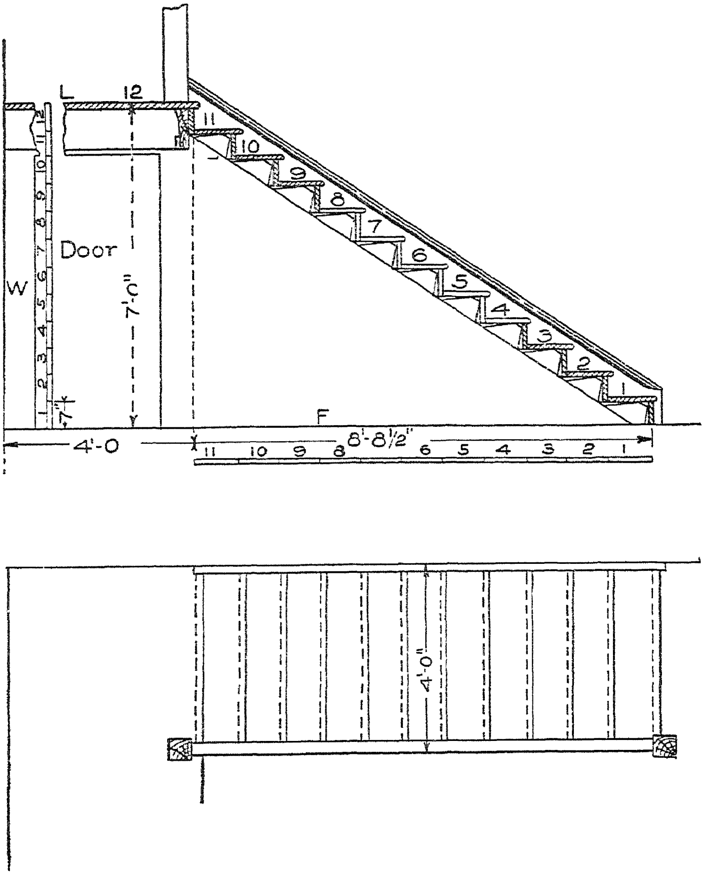


Fig 33 Method of Laying Out a Simple, Close-String Stair

deep; the treads and risers will require to be made 1¼ inches longer than shown in the plan, to allow for the housings at both ends.

Before putting the stair together, be sure that it can be taken into the house and put in position without trouble. If for any reason it cannot be put in after being put together, then the parts must be assembled, wedged, and glued up at the spot.

It is essential in laying out a plan on the floor, that the exact positions of the first and last risers be ascertained, and the height of the story wherein the stair is to be placed. Then draw a plan of the hall or other room in which the stairs will be located, including surrounding or adjoining parts of the room to the extent of ten or twelve feet from the place assigned for the foot of the stair. All the doorways, branching passages, or windows which can possibly come in contact with the stair from its commencement to its expected termination or landing, must be noted. The sketch must necessarily include a portion of the entrance hall in one part, and of the lobby or landing in another, and on it must be laid out all the lines of the stair from the first to the last riser.

The height of the story must next be exactly determined and taken on the rod; then, assuming a height of risers suitable to the place, a trial is made by division in the manner previously explained, to ascertain how often this height is contained in the height of the story The quotient, if there is no remainder, will be the number of risers required. Should there be a remainder on the first division, the operation is reversed, the number of inches in the height being made the dividend and the before-found quotient the divisor; and the operation of reduction by division is carried on till the height of the riser is obtained to the thirty-second part of an inch. These heights are then set off as exactly as possible on the story rod, as shown in Fig. 33.

The next operation is to show the risers on the sketch. This the workman will find no trouble in arranging, and no arbitrary rule can be given.

A part of the foregoing may appear to be repetition; but it is not, for it must be remembered that scarcely any two flights of stairs are alike in run, rise, or pitch, and any departure in any one dimension from these conditions leads to a new series of dimensions that must be dealt with independently. The principle laid down, however, applies to all straight flights of stairs; and the student who has followed closely and retained the pith of what has been said, will, if he has a fair knowledge of the use of tools, be fairly equipped for laying out and constructing a plain, straight stair with a straight rail.

Plain stairs may have one platform, or several; and they may turn to the right or to the left, or, rising from a platform or landing, may run in an opposite direction from their starting point.

When two flights are necessary for a story, it is desirable that each flight should consist of the same number of steps; but this, of course, will depend on the form of the staircase, the situation and height of doors, and other obstacles to be passed under or over, as the case may be.

In Fig. 32, a stair is shown with a single platform or landing and three newels. The first part of this stair corresponds, in number of risers, with the stair shown in Fig. 33; the second newel runs down to the floor, and helps to sustain the landing. This newel may simply by a 4 by 4-inch post, or the whole space may be inclosed with the spandrel of the stair. The second flight starts from the platform just as the first flight starts from the lower floor, and both flights may be attached to the newels in the manner shown in Fig 29. The bottom tread in Fig. 32 is rounded off against the square of the newel post; but this cannot well be if the stairs start from the landing, as the tread would project too far onto the platform. Sometimes, in high-class stairs, provision is made for the first tread to project well onto the landing.

If there are more platforms than one, the principles of construction will be the same; so that whenever the student grasps the full conditions governing the construction of a single-platform stair, he will be prepared to lay out and construct the body of any stair having one or more landings. The method of laying out, making, and setting up a hand-rail will be described later.

Stairs formed with treads each of equal width at both ends, are named *straight flights*; but stairs having treads wider at one end than the other are known by various names, as *winding stairs, dog-legged stairs, circular stairs,* or *elliptical stairs.* A tread with parallel sides, having the same width at each end, is called a *flyer;* while one having one wide end and one narrow, is called a *winder.* These terms will often be made use of in what follows.

The elevation and plan of the stair shown in Fig. 34 may be called a *dog-legged* stair with three winders and six flyers. The flyers, however, may be extended to any number. The housed strings to receive the winders are shown. These strings show exactly the manner of construction. The shorter string, in the corner from 1 to 4, which is shown in the plan to contain the housing of the first winder and half of the second, is put up first, the treads being leveled by aid of a spirit level; and the longer upper string is put in place afterwards, butting snugly against the lower string in the corner. It is then fastened firmly to the wall The winders are cut snugly around the newel post, and well nailed. Their risers will stand one above another on the post; and the straight string above the winders will enter the post on a line with the top edge of the uppermost winder.

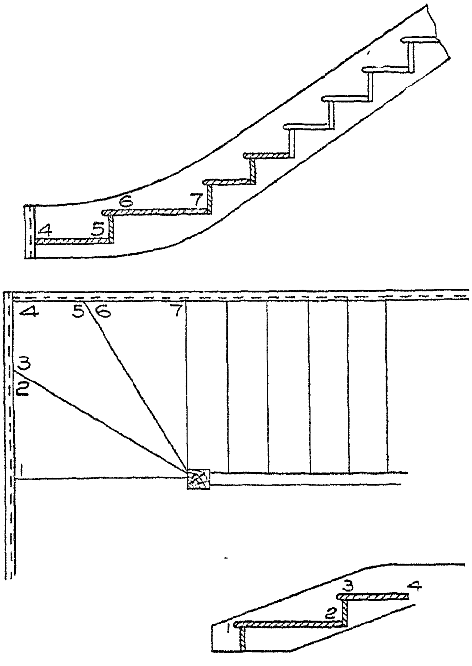


Fig. 34 Elevation and Plan of Dog-Legged Stair with Three Winders and Six Flyers.

Platform stairs are often constructed so that one flight will run in a direction opposite to that of the other flight, as shown in Fig. 35. In cases of this kind, the landing or platform requires to have a length more than double that of the treads, in order that both flights may have the same width. Sometimes, however, and for various reasons, the upper flight is made a little narrower than the lower; but this expedient should be avoided whenever possible, as its adoption unbalances the stairs. In the example before us, eleven treads, not including the landing, run in one direction; while four treads, including the landing, run in the opposite direction; or, as workmen put it, the stair "returns on itself." The elevation

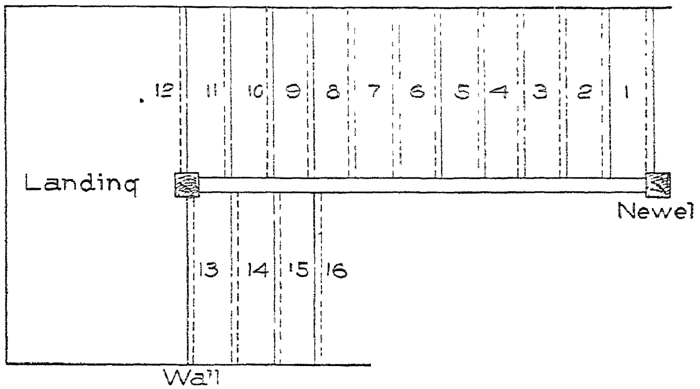


Fig. 35. Plan of Platform Stair Returning on Itself.

shown in Fig. 36 illustrates the manner in which the work is executed. The various parts are shown as follows:

Fig. 37 is a section of the top landing, with baluster and rail.

Fig. 38 is part of the long newel, showing mortises for the strings.

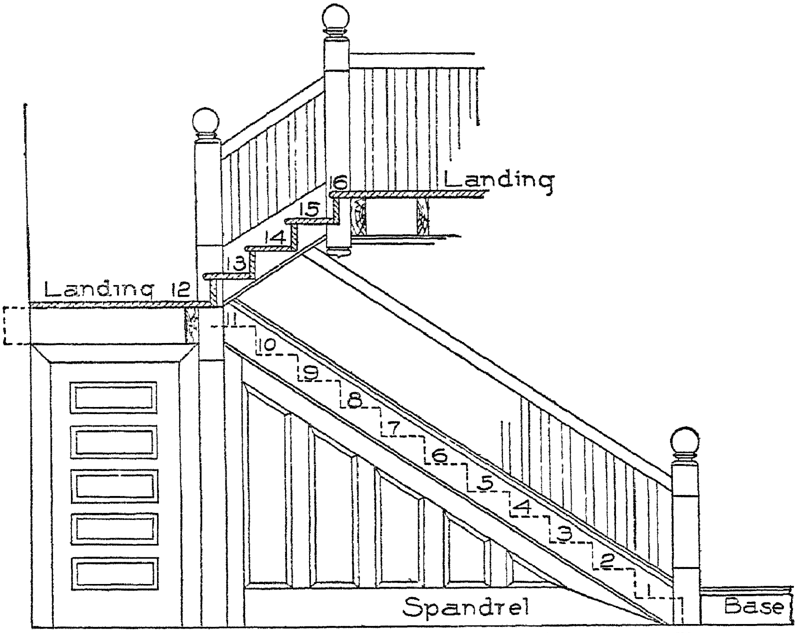


Fig. 36. Elevation Showing Construction of Platform Stair of which Plan is Given in Fig. 35.

Fig 39 represents part of the bottom newel, showing the string, moulding on the outside, and cap.

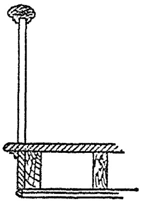


Fig 37 Section of Top Landing, Baluster, and Rail

Fig 40 is a section of the top string enlarged.

Fig. 41 is the newel at the bottom, as cut out to receive bottom step. It must be remembered that there is a *cove* under each tread. This may be nailed in after the stairs are put together, and it adds greatly to the appearance.

We may state that stairs should have *carriage pieces* fixed from floor to floor, under the stairs, to support them. These may be notched under the steps; or *rough brackets* may be nailed to the side of the carriage, and carried under each riser and tread.

There is also a framed spandrel which helps materially to carry the weight, makes a sound job, and adds greatly to the appearance. This spandrel may be made of 1¼-inch material, with panels and mouldings on the front side, as shown in Fig. 36. The joint between the top and bottom rails of the spandrel at the angle, should be made as shown in Fig. 42 with a cross-tongue, and glued and fastened with long screws. Fig. 43 is simply one of the panels showing the miters on the moulding and the shape of the sections. As there is a convenient space under the landing, it is commonly used for a closet.

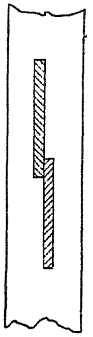


Fig 38 String Mortises in Long Newel.

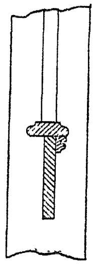


Fig. 39 Mortises in Lower Newel for String, Outside Moulding, and Cap

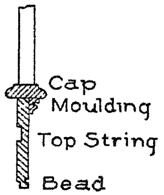


Fig. 40. Enlarged Section of Top String.

In setting out stairs, not only the proportions of treads and risers must be considered, but also the material available. As this material runs, as a rule, in certain sizes, it is best to work so as to conform to it as nearly as possible. In ordinary stairs, 11 by 1-inch common stock is used for strings and treads, and 7-inch by ¾-inch stock for risers; in stairs of a better class, wider and thicker material may be used. The rails are set at various heights; 2 feet 8 inches may be taken as an average height on the stairs, and 3 feet 1 inch on landings, with two balusters to each step.

In Fig. 36, all the newels and balusters are shown square; but it is much better, and is the more common practice, to have them turned, as this gives the stairs a much more artistic appearance. The spandrel under the string of the stairway shows a style in which many stairs are finished in hallways and other similar places. Plaster is sometimes used instead of the panel work, but is not nearly so good as woodwork. The door under the landing may open into a closet, or may lead to a cellarway, or through to some other room.

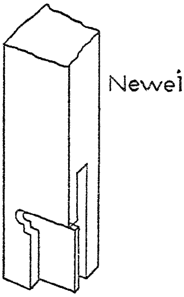


Fig 41 Newel Cut to Receive Bottom Step

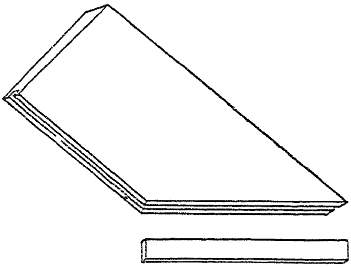


Fig 42 Showing Method of Joining Spandrel Rails with Cross Tongue Glued and Screwed

In stairs with winders, the width of a winder should, if possible, be nearly the width of the regular tread, at a distance of 14 inches from the narrow end, so that the length of the step in walking up or down the stairs may not be interrupted; and for this reason and several others, it is always best to have three winders only in each quarter-turn. Above all, avoid a four-winder turn, as this makes a breakneck stair, which is more difficult to construct and inconvenient to use.

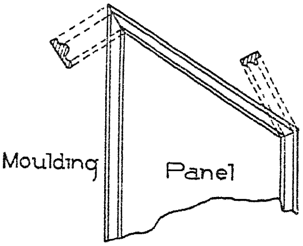


Fig 43 Panel in Spandrel, Showing Miters on Moulding, and Shape of Section

Bullnose Tread. No other stair, perhaps, looks so well at the starting point as one having a *bullnose* step. In Fig. 44 are shown a plan and elevation of a flight of stairs having a bullnose tread. The method of obtaining the lines and setting out the body of the stairs, is the same as has already been explained for other stairs, with the exception of the first two steps, which are made with circular ends, as shown in the plan. These circular ends are worked out as hereafter described, and are attached to the newel and string as shown.

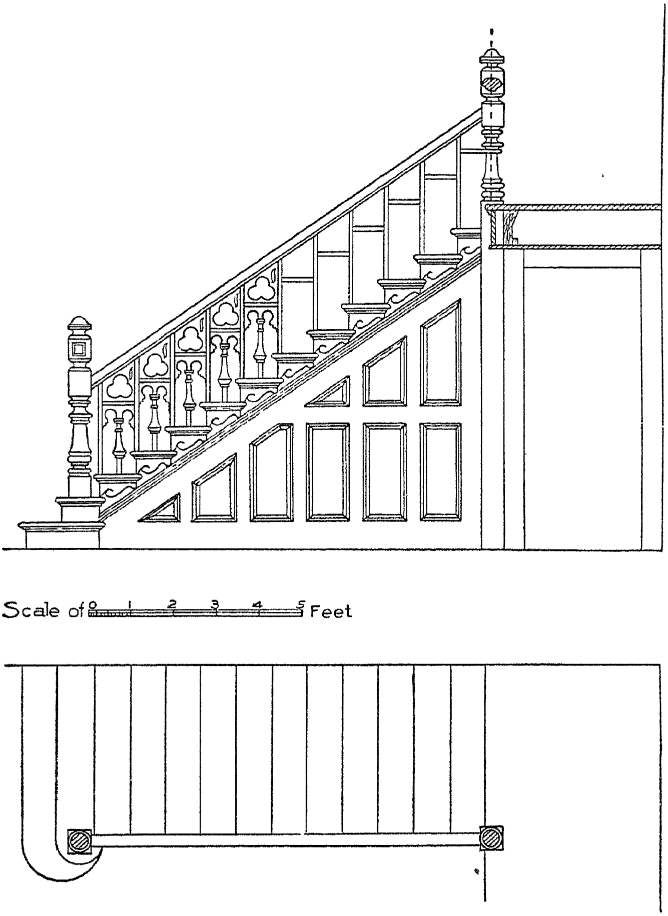


Fig. 44 Elevation and Plan of Stair with Bullnose Tread.

The example shows an open, cut string with brackets. The spandrel under the string contains short panels, and makes a very handsome finish. The newels and balusters in this case are turned, and the latter have cutwork panels between them.

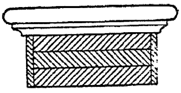


Fig. 45 Section through Bullnose Step.

Bullnose steps are usually built up with a three-piece block, as shown in Fig. 45, which is a section through the step indicating the blocks, tread, and riser.

Fig. 46 is a plan showing how the veneer of the riser is prepared before being bent into position. The block A indicates a wedge which is glued and driven home after the veneer is put in place. This tightens up the work and makes it sound and clear. Figs. 47 and 48 show other methods of forming bullnose steps.

Fig. 49 is the side elevation of an open-string stair with bullnose steps at the bottom; while Fig. 50 is a view showing the lower end of the string, and the manner in which it is prepared for fixing to the blocks of the step. Fig. 51 is a section through the string, showing the bracket, cove, and projection of tread over same.

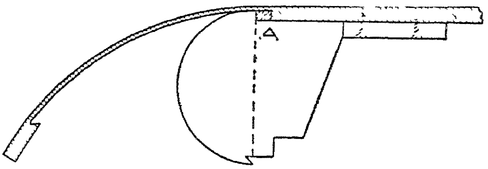


Fig. 46 Plan Showing Preparation of Veneer before Bending into Position.

Figs. 52 and 53 show respectively a plan and vertical section of the bottom part of the stair. The blocks are shown at the ends of the steps (Fig. 53), with the veneered parts of the risers going round them; also the position where the string is fixed to the blocks (Fig. 52); and the tenon of the newel is marked on the upper step. The section (Fig. 53) shows the manner in which the blocks are built up and the newel tenoned into them.

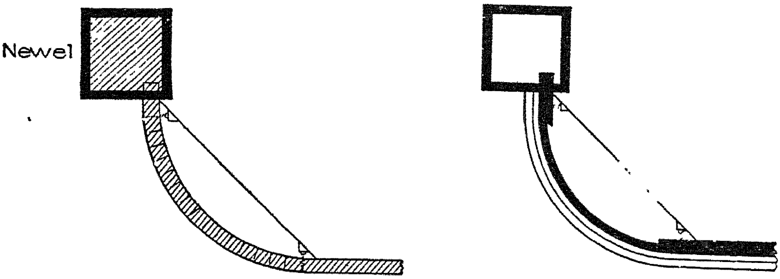


Fig 47. Fig 48

Methods of Forming Bullnose Steps.

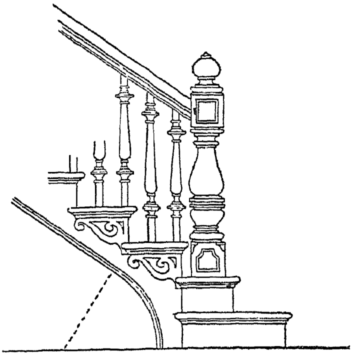


Fig. 49. Side Elevation of Open-String Stair with Bullnose Steps

The newel, Fig. 49, is rather an elaborate affair, being carved at the base and on the body, and having a carved rosette planted in a small, sunken panel on three sides, the rail butting against the fourth side.

Open-Newel Stairs. Before leaving the subject of straight and dog-legged stairs, the student should be made familiar with at least one example of an open-newel stair. As the same principles of construction govern all styles of open-newel stairs, a single example will be sufficient. The student must, of course, understand that he himself is the greatest factor in planning stairs of this type; that the setting out and designing will generally devolve on him. By exercising a little thought and foresight, he can so arrange his plan that a minimum of both labor and material will be required.

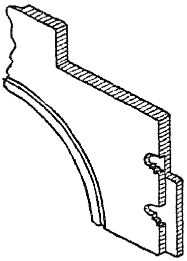


Fig. 50. Lower End of String to Connect with Bullnose Step.

Fig. 54 shows a plan of an open-newel stair having two landings and closed strings, shown in elevation in Fig. 55. The dotted lines show the carriage timbers and trimmers, also the lines of risers; while the treads are shown by full lines. It will be noticed that the strings and trimmers at the first landing are framed into the shank of the second newel post, which runs down to the floor; while the top newel drops below the fascia, and has a turned and carved drop. This drop hangs below both the fascia and the string. The lines of treads and risers are shown by dotted lines and crosshatched sections. The position of the carriage timbers is shown both in the landings and in the runs of the stairs, the projecting ends of these timbers being supposed to be resting on the wall. A scale of the plan and elevation is attached to the plan. In Fig. 55, a story rod is shown at the right, with the number of risers spaced off thereon. The design of the newels, spandrel, framing, and paneling is shown.

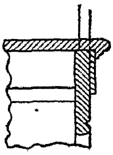


Fig. 51. Section through String

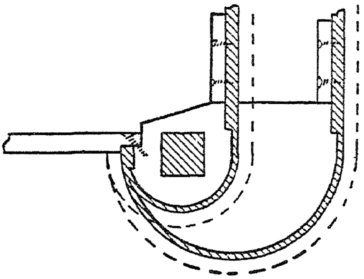


Fig. 52 Plan of Bottom Part of Bullnose Stair

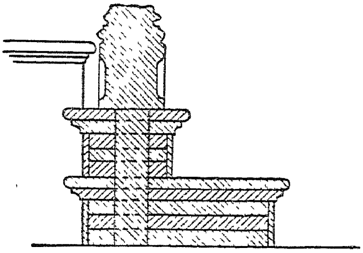


Fig 53 Vertical Section through Bottom Part of Bullnose Stair

Only the central carriage timbers are shown in Fig. 54; but in a stair of this width, there ought to be two other timbers, not so heavy, perhaps, as the central one, yet strong enough to be of service in lending additional strength to the stairway, and also to help carry the laths and plaster or the paneling which may be necessary in completing the under side or soffit. The strings being closed, the butts of their balusters must rest on a subrail which caps the upper edge of the outer string.

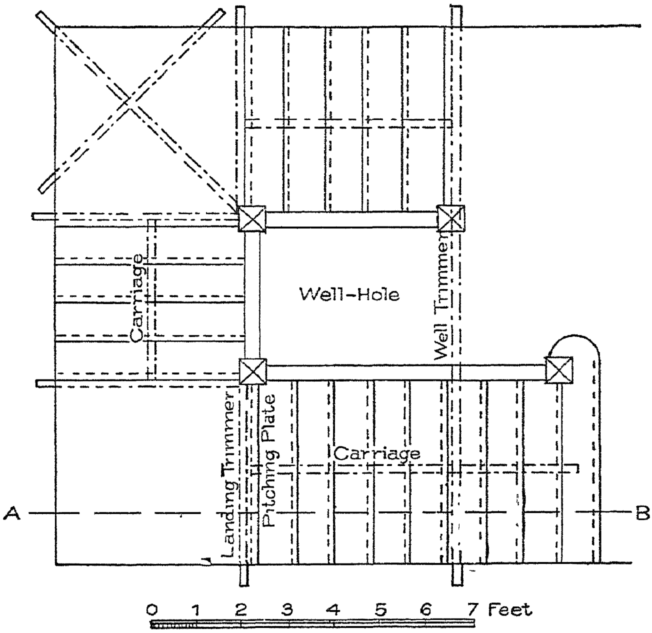


Fig. 54. Plan of Open-Newel Stair, with Two Landings and Closed Strings.

The first newel should pass through the lower floor, and, to insure solidity, should be secured by bolts to a joist, as shown in the elevation. The rail is attached to the newels in the usual manner, with handrail bolts or other suitable device. The upper newel should be made fast to the joists as shown, either by bolts or in some other efficient manner. The intermediate newels are left square on the shank below the stairs, and may be fastened in the floor below either by mortise and tenon or by making use of joint bolts.

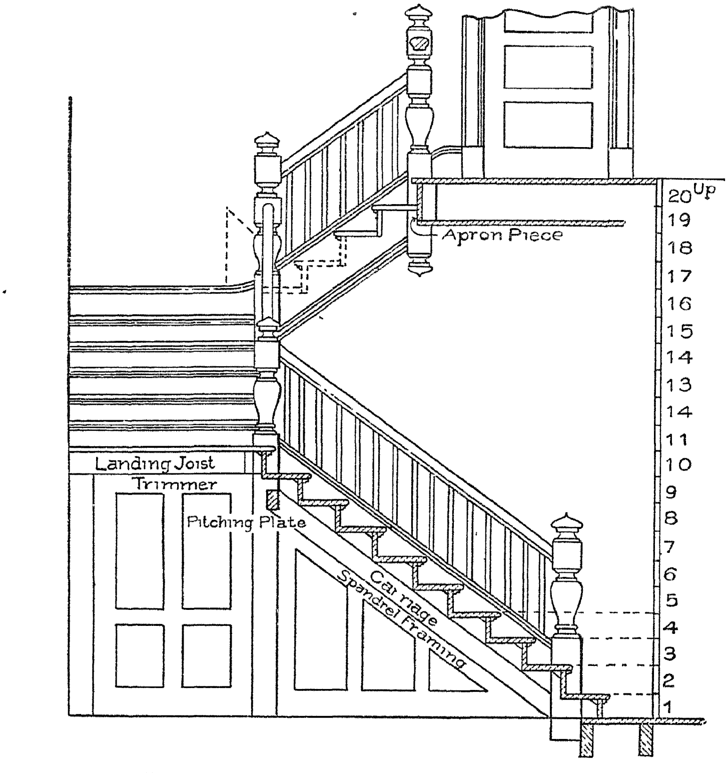
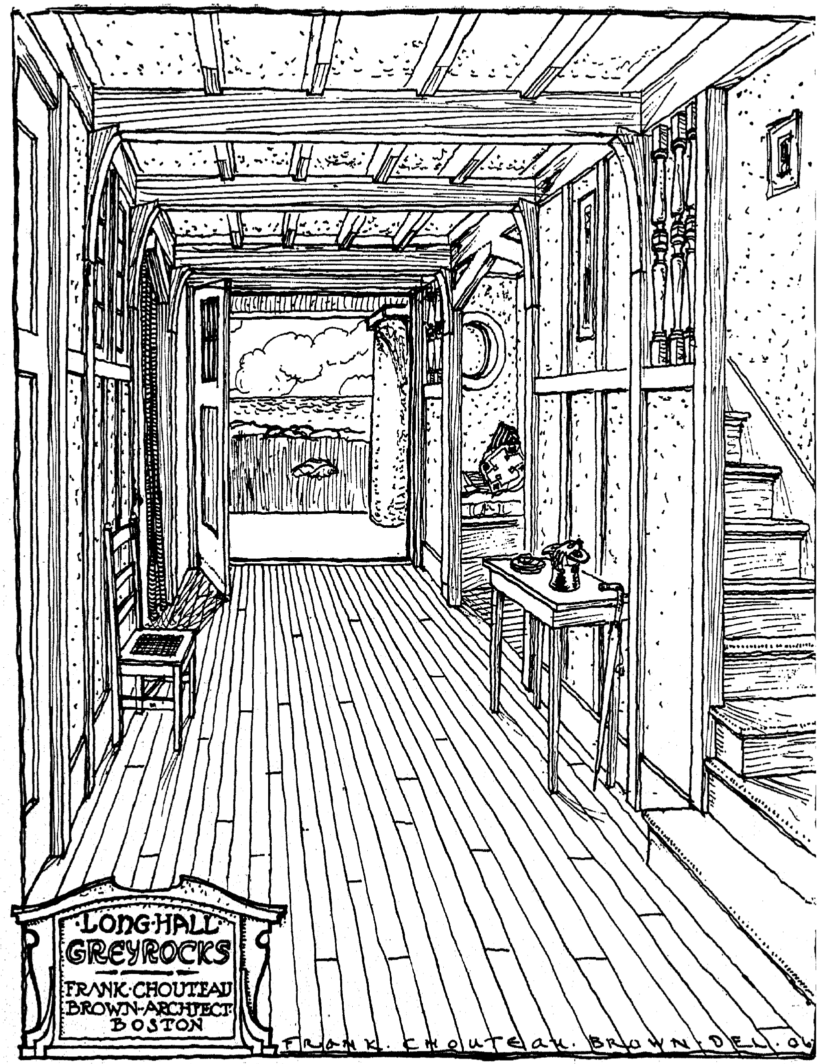


Fig. 55. Elevation of Open-Newel Stair Shown in Plan in Fig. 54.

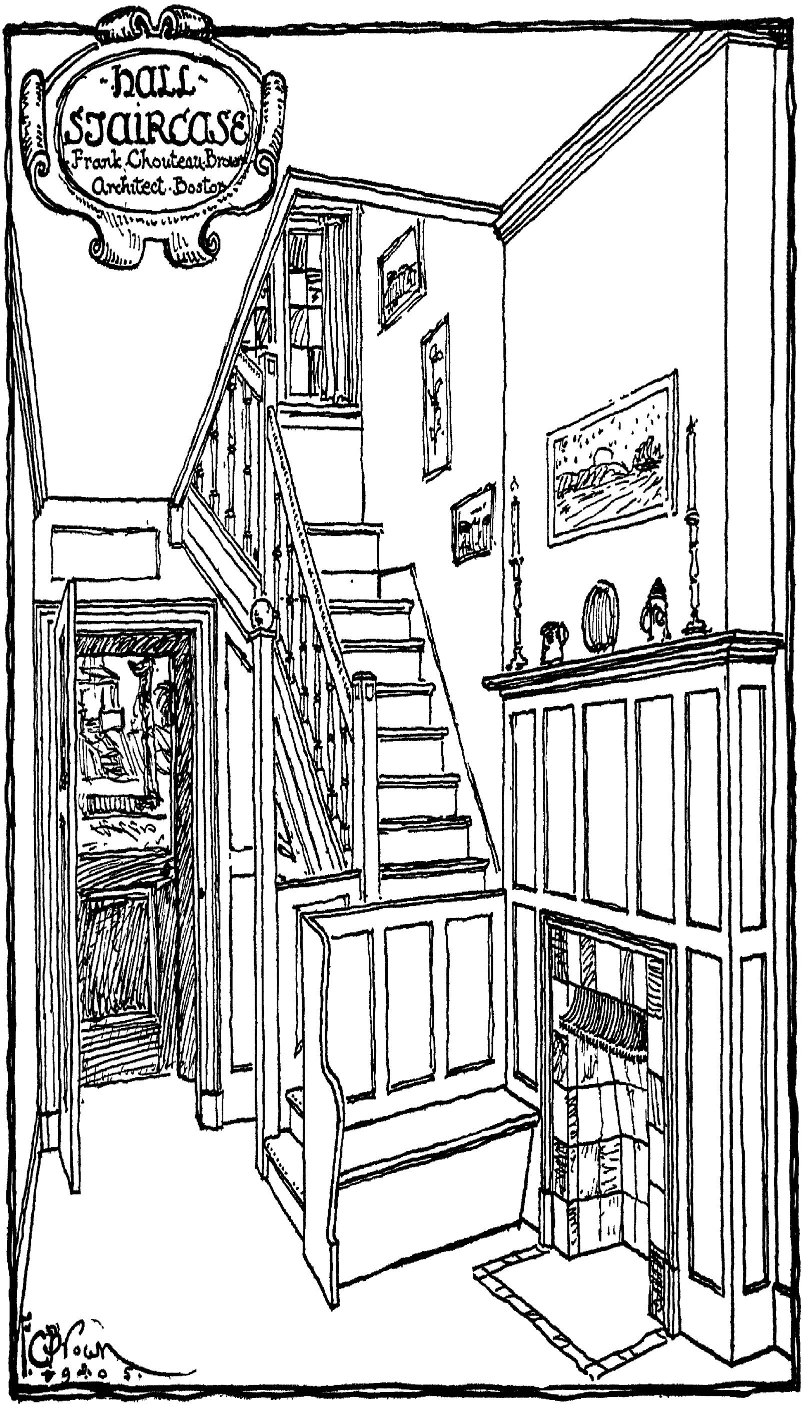
Everything about a stair should be made solid and sound; and every joint should set firmly and closely; or a shaky, rickety, squeaky stair will be the result, which is an abomination.

Stairs with Curved Turns. Sufficient examples of stairs having angles of greater or less degree at the turn or change of direction, to



HALL AND PARTIALLY ENCLOSED STAIRCASE IN LONG HALL, GREYROCKS, ROCKPORT, MASS

Frank Chouteau Brown, Architect, Boston, Mass.
For Plans and Exteriors, See Vol. I, Pages 272, 282, and 299.



HALL AND STAIRCASE IN HOUSE AT WOLLASTON, MASS.

Frank Chouteau Brown, Architect

enable the student to build any stair of this class, have now been given. There are, however, other types of stairs in common use, whose turns are curved, and in which newels are employed only at the foot, and sometimes at the finish of the flight. These curved turns may be any part of a circle, according to the requirements of the case, but turns of a quarter-circle or half-circle are the more common. The string forming the curve is called a *cylinder*, or part of a cylinder, as the case may be. The radius of this circle or cylinder may be any length, according to the space assigned for the stair. The opening around which the stair winds is called the *well-hole*.

Fig. 56 shows a portion of a stairway having a well-hole with a 7-inch radius. This stair is rather peculiar, as it shows a quarter-space landing, and a quarter-space having three winders. The reason for this is the fact that the landing is on a level with the floor of another room, into which a door opens from the landing. This is a problem very often met with in practical work, where the main stair is often made to do the work of two flights because of one floor being so much lower than another.

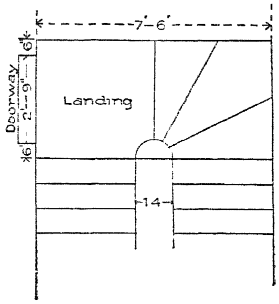


Fig. 56. Stair Serving for Two Flights with Mid-Floor Landing.

A curved stair, sometimes called a *geometrical stair*, is shown in Fig. 57, containing seven winders in the cylinder or well-hole, the first and last aligning with the diameter.

In Fig. 58 is shown another example of this kind of stair, containing nine winders in the well-hole, with a circular wall-string. It is not often that stairs are built in this fashion, as most stairs having a circular well-hole finish against the wall in a manner similar to that shown in Fig. 57.

Sometimes, however, the workman will be confronted with a plan such as shown in Fig. 58; and he should know how to lay out the wall-string. In the elevation, Fig. 58, the string is shown to be straight, similar to the string of a common straight flight. This results from having an equal width in the winders along the wall-string, and, as we have of necessity an equal width in the risers, the development of the string is merely a straight piece of board, as in an ordinary straight flight. In laying out the string, all we have to do is to make a common pitch-board, and, with it as a templet, mark the lines of the treads and risers on a straight piece of board, as shown at 1, 2, 3, 4, etc.

If you can manage to bend the string without kerfing (grooving), it will be all the better; if not, the kerfs (grooves) must be parallel to the rise. You can set out with a straight edge, full size, on a rough platform, just as shown in the diagram; and when the string is bent and set in place, the risers and winders will have their correct positions.

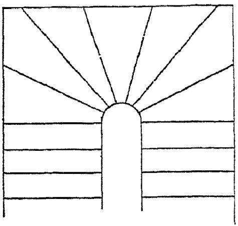


Fig 57 Geometrical Stair with Seven Winders

To bend these strings or otherwise prepare them for fastening against the wall, perhaps the easiest way is to saw the string with a fine saw, across the face, making parallel grooves. This method of bending is called *kerfing*, above referred to. The kerfs or grooves must be cut parallel to the lines of the risers, so as to be vertical when the string is in place. This method, however—handy though it may be—is not a good one, inasmuch as the saw groove will show more or less in the finished work.

Another method is to build up or *stave* the string. There are several ways of doing this. In one, comparatively narrow pieces are cut to the required curve or to portions of it, and are fastened together, edge to edge, with glue and screws, until the necessary width is obtained (see Fig. 59). The heading joints may be either butted or beveled, the latter being stronger, and should be cross-tongued.

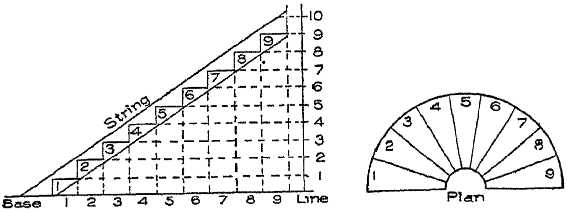


Fig. 58 Plan of Circular Stair and Layout of Wall String for Same.

Fig. 60 shows a method that may be followed when a wide string is required, or a piece curved in the direction of its width is needed for any purpose. The pieces are stepped over each other to suit the desired curve; and though shown square-edged in the figure, they are usually cut beveled, as then, by reversing them, two may be cut out of a batten.

Panels and quick sweeps for similar purposes are obtained in the manner shown in Fig. 61, by joining up narrow boards edge to edge at a suitable bevel to give the desired curve. The internal curve is frequently worked approximately, before gluing up. The numerous joints incidental to these methods limit their uses to painted or unimportant work.

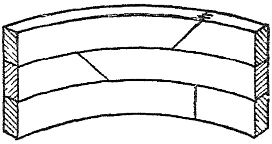


Fig 59

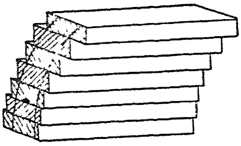


Fig 60

Methods of Building Up Strings.

In Fig. 62 is shown a wreath-piece or curved portion of the outside string rising around the cylinder at the half-space. This is formed by reducing a short piece of string to a veneer between the springings; bending it upon a cylinder made to fit the plan; then, when it is secured in position, filling up the back of the veneer with staves glued across it; and, finally, gluing a piece of canvas over the whole. The appearance of the wreath-piece after it has been built up and removed from the cylinder is indicated in Fig. 63. The canvas back has been omitted to show the staving; and the counter-wedge key used for connecting the wreath-piece with the string is shown. The wreath-piece is, at this stage, ready for marking the outlines of the steps.

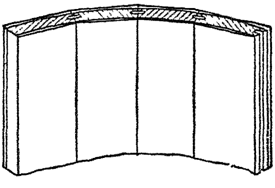


Fig. 61 Building Up a Curved Panel or Quick Sweep

Fig. 62 also shows the drum or shape around which strings may be bent, whether the strings are formed of veneers, staved, or kerfed. Another drum or shape is shown in Fig. 64. In this, a portion of a cylinder is formed in the manner clearly indicated; and the string, being set out on a veneer board sufficiently thin to bend easily, is laid down round the curve, such a number of pieces of like thickness being then added as will make the required thickness of the string. In working this method, glue is introduced between the veneers, which

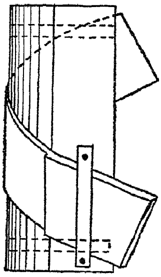


Fig. 62 Wreath-Piece Bent around Cylinder

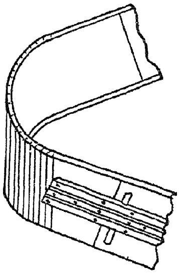


Fig. 63 Completed Wreath-Piece Removed from Cylinder.

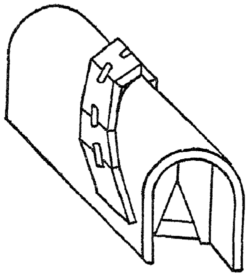


Fig. 64 Another Drum or Shape for Building Curved Strings

are then quickly strained down to the curved piece with hand screws. A string of almost any length can be formed in this way, by gluing a few feet at a time, and when that dries, removing the cylindrical curve and gluing down more, until the whole is completed. Several other methods will suggest themselves to the workman, of building up good, solid, circular strings.

One method of laying out the treads and risers around a cylinder or drum, is shown in Fig. 65. The line *D* shows the curve of the rail. The lines showing treads and risers may be marked off on the cylinder, or they may be marked off after the veneer is bent around the drum or cylinder.

There are various methods of making inside cylinders or wells, and of fastening same to strings. One method is shown in Fig. 66. This gives a strong joint when properly made. It will be noticed that the cylinder is notched out on the back; the two blocks shown at the back of the offsets are wedges driven in to secure the cylinder in place, and to drive it up tight to the strings. Fig. 67 shows an 8-inch well-hole with cylinder complete; also the method of trimming and finishing same. The cylinder, too, is shown in such a manner that its construction will be readily understood.

Stairs having a cylindrical or circular opening always require a weight support underneath them. This support, which is generally made of rough lumber, is called the *carriage*, because it is supposed to carry any reasonable load that may be placed upon the stairway. Fig. 68 shows the under side of a half-space stair having a carriage beneath it. The timbers marked *S* are of rough stuff, and may be 2-inch by 6-inch or of greater dimensions. If they are cut to fit the risers and treads, they will require to be at least 2-inch by 8-inch.

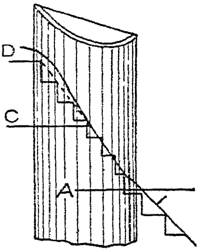


Fig 65. Laying Out Treads and Risers around a Drum.

In preparing the rough carriage for the winders, it will be best to let the back edge of the tread project beyond the back of the riser so that it forms a ledge as shown under *C* in Fig. 69. Then fix the cross-carriage pieces under the winders, with the back edge about flush with the backs of risers, securing one end to the well with screws, and the other to the wall string or the wall. Now cut short pieces, marked *O O* (Fig. 68), and fix them tightly in between the cross-carriage and the back of the riser as at *B B* in the section, Fig. 69. These carriages should be of 3-inch by 2-inch material. Now get a piece of wood, 1-inch by 3-inch, and cut pieces *C C* to fit tightly between the top back edge of the winders (or the ledge) and the pieces marked *B B* in section. This method makes a very sound and strong job of the winders; and if the stuff is roughly planed, and blocks are glued on each side of the short cross-pieces *O O O*, it is next to impossible for the winders ever to spring or squeak. When the weight is carried in this manner, the plasterer will have very little trouble in lathing so that a graceful soffit will be made under the stairs.

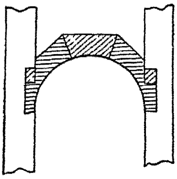


Fig 66 One Method of Making an Inside Well.

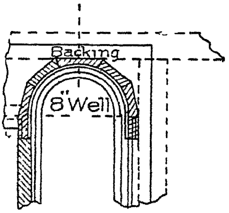


Fig. 67 Construction and Trimming of 8-Inch Well-Hole.

The manner of placing the main stringers of the carriage *S S*, is shown at *A*, Fig. 69. Fig. 68 shows a complete half-space stair;

one-half of this, finished as shown, will answer well for a quarter-space stair.

Another method of forming a carriage for a stair is shown in Fig. 70. This is a peculiar but very handsome stair, inasmuch as the first and the last four steps are parallel, but the remainder *balance* or *dance*. The treads are numbered in this illustration; and the plan of the handrail is shown extending from the scroll at the bottom of the stairs to the landing on the second story. The trimmer *T* at the top of the stairs is also shown; and the rough strings or carriages, *R S*, *R S*, *R S*, are represented by dotted lines.

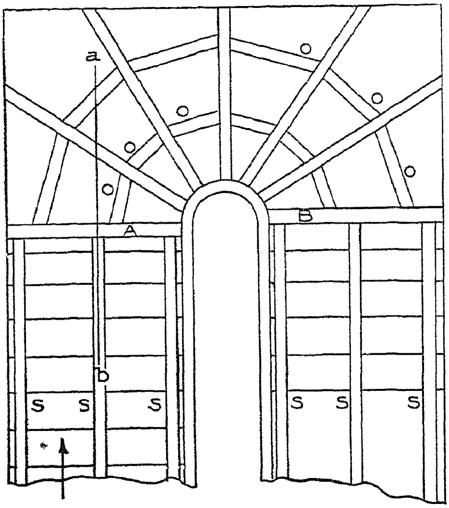


Fig 68. Under Side of Half-Space Stair, with Carriages and Cross-Carriages

This plan represents a stair with a curtail step, and a scroll handrail resting over the curve of the curtail step. This type of stair is not now much in vogue in this country, though it is adopted occasionally in some of the larger cities. The use of heavy newel posts instead of curtail steps, is the prevailing style at present.

In laying out geometrical stairs, the steps are arranged on principles already described. The well-hole in the center is first laid down and the steps arranged around it. In circular stairs with an open well-hole, the handrail being on the inner side, the width of tread for the steps should be set off at about 18 inches from the handrail, this giving an approximately uniform rate of progress for anyone ascending or descending the stairway. In stairs with the rail on the outside, as sometimes occurs, it will be sufficient if the treads have the proper width at the middle point of their length.

Where a flight of stairs will likely be subject to great stress and wear, the carriages should be made much heavier than indicated in the foregoing figures; and there may be cases when it will be necessary to use iron bolts in the sides of the rough strings in order to give them greater strength. This necessity, however, will arise only in the case of stairs built in public buildings, churches, halls, factories, warehouses, or other buildings of a similar kind Sometimes, even in house stairs, it may be wise to strengthen the treads and risers by spiking pieces of board to the rough string, ends up, fitting them snugly against the under side of the tread and the back of the riser. The method of doing this is shown in Fig. 71, in which the letter *O* shows the pieces nailed to the string.

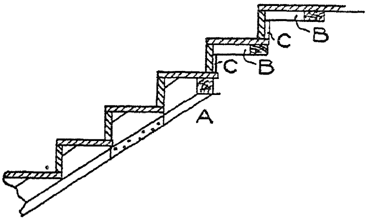


Fig 69 Method of Reinforcing Stair.

Types of Stairs in Common Use. In order to make the student familiar with types of stairs in general use at the present day, plans of a few of those most likely to be met with will now be given.

Fig. 72 is a plan of a straight stair, with an ordinary cylinder at the top provided for a return rail on the landing. It also shows a stretch-out stringer at the starting.

Fig. 73 is a plan of a stair with a landing and return steps.

Fig. 74 is a plan of a stair with an acute angular landing and cylinder.

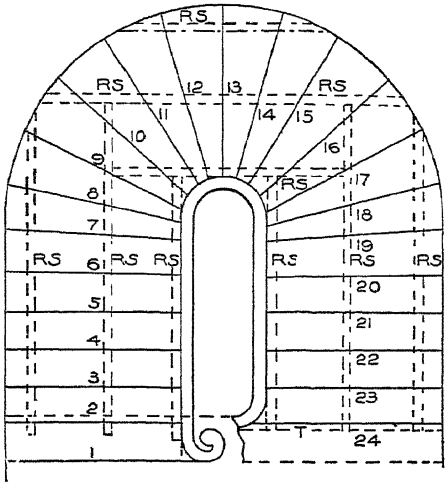


Fig. 70 Plan Showing One Method of Constructing Carriage and Trimming Winding Stair.

Fig. 75 illustrates the same kind of stair as Fig. 74, the angle, however, being obtuse.

Fig. 76 exhibits a stair having a half-turn with two risers on landings.

Fig. 77 is a plan of a quarter-space stair with four winders.

Fig. 78 shows a stair similar to Fig. 77, but with six winders.

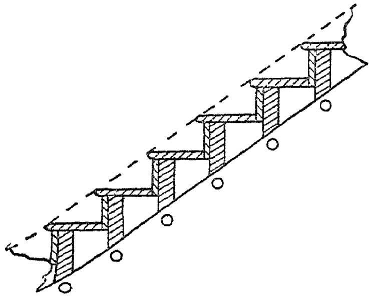


Fig. 71. Reinforcing Treads and Risers by Blocks Nailed to String

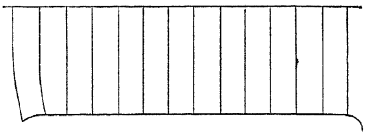


Fig. 72. Plan of Straight Stair with Cylinder at Top for Return Rail

Fig. 79 shows a stair having five dancing winders.

Fig. 80 is a plan of a half-space stair having five dancing winders and a quarter-space landing.

Fig. 81 shows a half-space stair with dancing winders all around the cylinder.

Fig. 82 shows a geometrical stair having winders all around the cylinder.

Fig. 83 shows the plan and elevation of stairs which turn around a central post. This kind of stair is frequently used in large stores and in clubhouses and other similar places, and has a very graceful appearance. It is not very difficult to build if properly planned.

The only form of stair not shown which the student may be called upon to build, would very likely be one having an elliptical plan; but, as this form is so seldom used—being found, in fact, only in public buildings or great mansions—it rarely falls to the lot of the ordinary workman to be called upon to design or construct a stairway of this type.

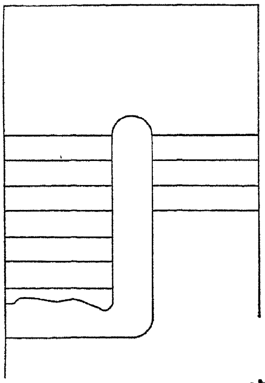


Fig. 73. Plan of Stair with Landing and Return Steps.

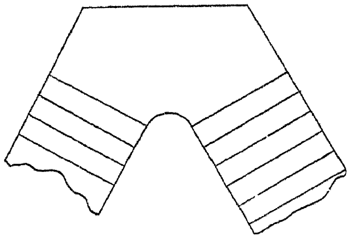


Fig. 74. Plan of Stair with Acute-Angle Landing and Cylinder.

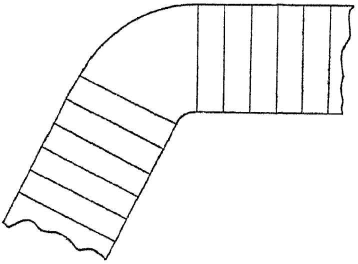


Fig. 75. Plan of Stair with Obtuse Angle Landing and Cylinder.

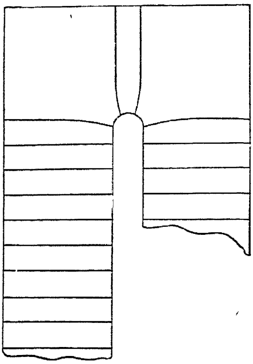


Fig 76 Half-Turn Stair with Two Risers on Landings

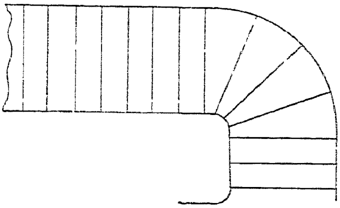


Fig 77 Quarter-Space Stair with Four Winders

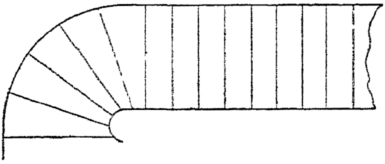


Fig 79. Stair with Five Dancing Winders

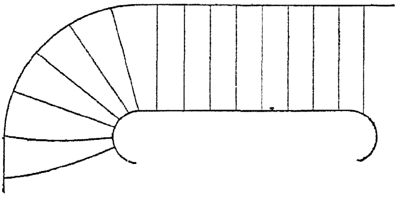


Fig. 78 Quarter-Space Stair with Six Winders.

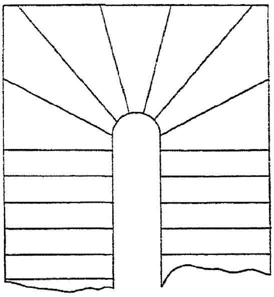


Fig 81 Half-Space Stair with Dancing Winders all around Cylinder

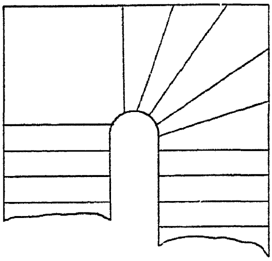


Fig. 80 Half-Space Stair with Five Dancing Winders and Quarter-Space Landing.

GEOMETRICAL STAIRWAYS AND HANDRAILING

The term *geometrical* is applied to stairways having any kind of curve for a plan. The rails over the steps are made continuous from one story to another. The resulting winding or twisting pieces are called *wreaths.*

Wreaths. The construction of wreaths is based on a few geometrical problems—namely, the projection of straight and curved lines into an oblique plane; and the finding of the angle of inclination of the plane into which the lines and curves are projected. This angle

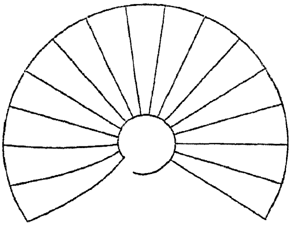


Fig. 82 Geometrical Stair with Winders all Around Cylinder

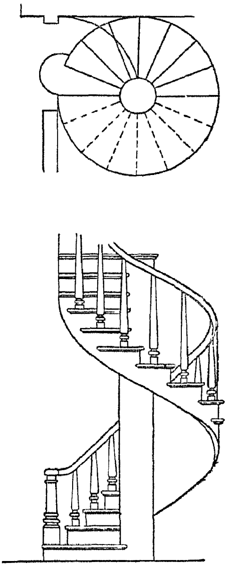


Fig 83 Plan and Elevation of Stairs Turning around a Central Post.

is called the *bevel,* and by its use the wreath is made to twist.

In Fig. 84 is shown an obtuse-angle plan; in Fig. 85, an acute-angle plan; and in Fig. 86, a semicircle enclosed within straight lines.

Projection. A knowledge of how to project the lines and curves in each of these plans into an oblique plane, and to find the angle of inclination of the plane, will enable the student to construct any and all kinds of wreaths.

The straight lines *a, b, c, d* in the plan, Fig. 86, are known as *tangents;* and the curve, the *central line* of the plan wreath.

The straight line across from *n* to *n* is the *diameter;* and the perpendicular line from it to the lines *c* and *b* is the *radius.*

A *tangent* line may be defined as a line touching a curve without cutting it, and is made use of in handrailing to square the joints of the wreaths.

Tangent System. The *tangent system* of handrailing takes its name from the use made of the tangents for this purpose.

In Fig. 86, it is shown that the joints connecting the central line of rail with the plan rails *w* of the straight flights, are placed right at the springing; that is, they are in line with the diameter of the semicircle, and square to the side tangents *a* and *d.*

The center joint of the crown tangents is shown to be square to tangents *b* and *c.* When these lines are projected into an oblique plane, the joints of the wreaths can be made to butt square by applying the bevel to them.

All handrail wreaths are assumed to rest on an oblique plane while ascending around a well-hole, either in connecting two flights or in connecting one flight to a landing, as the case may be.

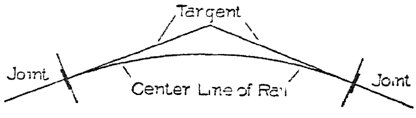


Fig 84 Obtuse-Angle Plan

In the simplest cases of construction, the wreath rests on an inclined plane that inclines in one direction only, to either side of the well-hole; while in other cases it rests on a plane that inclines to two sides.

Fig. 87 illustrates what is meant by a plane inclining in one direction. It will be noticed that the lower part of the figure is a reproduction of the quadrant enclosed by the tangents *a* and *b* in Fig. 86. The quadrant, Fig. 87, represents a central line of a wreath that is to ascend from the joint on the plan tangent *a* the height of *h* above the tangent *b*.

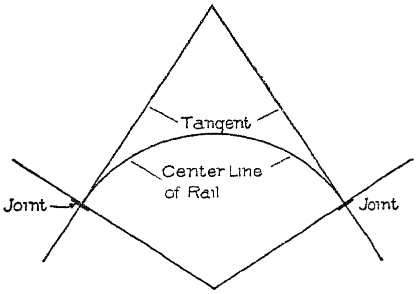


Fig 85 Acute-Angle Plan.

In Fig. 88, a view of Fig. 87 is given in which the tangents *a* and *b* are shown in plan, and also the quadrant representing the plan central line of a wreath. The curved line extending from *a* to *h* in this figure represents the development of the central line of the plan wreath, and, as shown, it rests on an oblique plane inclining to one side only—namely, to the side of the plan tangent *a*. The joints are made square to the developed tangents *a* and *m* of the inclined plane; it is for this purpose only that tangents are made use of in wreath construction. They are shown in the figure to consist of two lines, *a* and *m*, which are two adjoining sides of a developed section (in

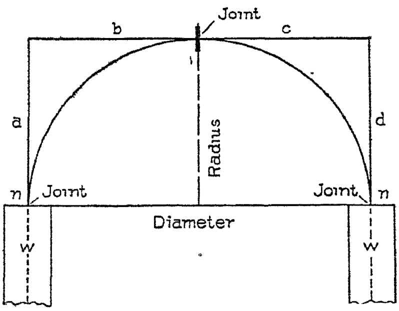


Fig. 86 Semicircular Plan.

this case, of a square prism), the section being the assumed inclined plane whereon the wreath rests in its ascent from *a* to *h*. The joint at *h*, if made square to the tangent *m*, will be a true, square butt-joint; so also will be the joint at *a*, if made square to the tangent *a*.

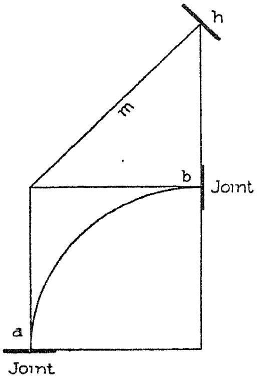


Fig. 87 Illustrating Plane Inclined in One Direction Only.

In practical work it will be required to find the correct goemetrical angle between the two developed tangents *a* and *m*; and here, again, it may be observed that the finding of the correct angle between the two developed tangents is the essential purpose of every tangent system of handrailing.

In Fig. 89 is shown the geometrical solution—the one necessary to find the angle between the tangents as required on the face-mould to square the joints of the wreath. The figure is shown to be similar to Fig. 87, except that it has an additional portion marked "Section." This section is the true shape of the oblique plane whereon the wreath ascends, a view of which is given in Fig. 88. It will be observed that one side of it is the developed tangent *m*, another side, the developed tangent a'' (= *a*). The angle between the two as here presented is the one required on the face-mould to square the joints.

In this example, Fig. 89, owing to the plane being oblique in one direction only, the shape of the section is found by merely drawing the tangent a'' at right angles to the tangent *m*, making it equal in length to the level tangent *a* in the plan. By drawing lines parallel to a'' and *m* respectively, the form of the section will be found, its outlines being the projections of the plan lines; and the angle between the two tangents, as already said, is the angle required on the face-mould to square the joints of the wreath.

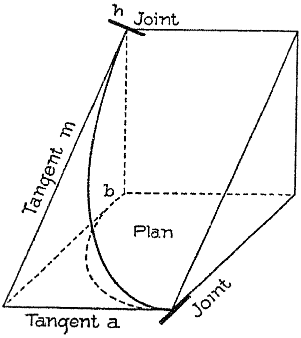


Fig 88 Plan Line of Rail Projected into Oblique Plane Inclined to One Side Only.

The solution here presented will enable the student to find the correct direction of the tangents as required on the face-mould to square joints, in all cases of practical work where one tangent of a wreath is level and the other tangent is inclined, a condition usually met with in level-landing stairways.

Fig. 90 exhibits a condition of tangents where the two are equally inclined. The plan here also is taken from Fig. 86. The inclination of the tangents is made equal to the inclination of tangent b in Fig. 86, as shown at m in Figs. 87, 88, and 89.

In Fig. 91, a view of Fig. 90 is given, showing clearly the inclination of the tangents c'' and d'' over and above the plan tangents c and d. The central line of the wreath is shown extending along the sectional plane, over and above its plan lines, from one joint to the other, and, at the joints, made square to the inclined tangents c'' and d''. It is evident from the view here given, that the condition necessary to square the joint at each end would be to find the true angle between the tangents c'' and d'', which would give the correct direction to each tangent.

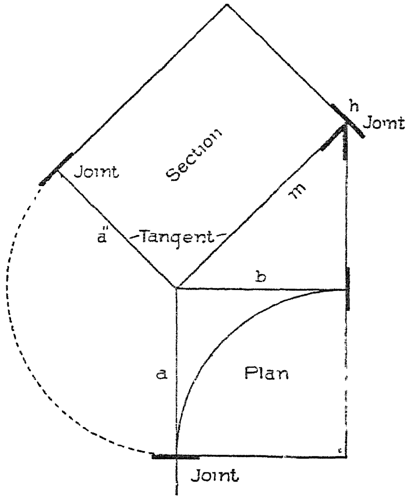


Fig. 89. Finding Angle between Tangents.

In Fig. 92 is shown how to find this angle correctly as required on the face-mould to square the joints. In this figure is shown the same plan as in Figs. 90 and 91 and the same inclination to the tangents as in Fig. 90, so that, except for the portion marked "Section," it would be similar to Fig. 90.

To find the correct angle for the tangents of the face-mould, draw the line m from d, square to the inclined line of the tangents c' d''; revolve the bottom inclined tangent c' to cut line m in n, where the joint is shown fixed; and from this point draw the line c'' to w. The intersection of this line with the upper tangent d'' forms the correct angle as required on the face-mould. By drawing the joints square to these two lines, they will butt square with the rail that is to connect

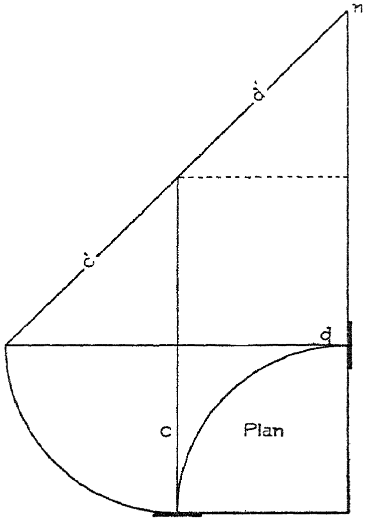


Fig. 90 Two Tangents Equally Inclined

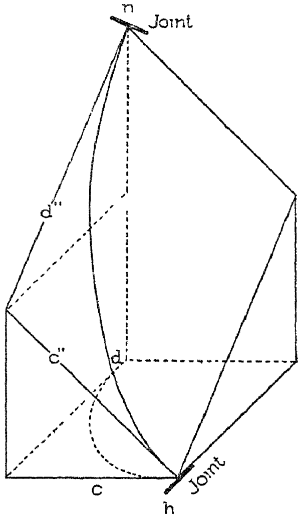


Fig 91 Plan Lines Projected into Oblique Plane Inclined to Two Sides.

with them, or to the joint of another wreath that may belong to the cylinder or well-hole.

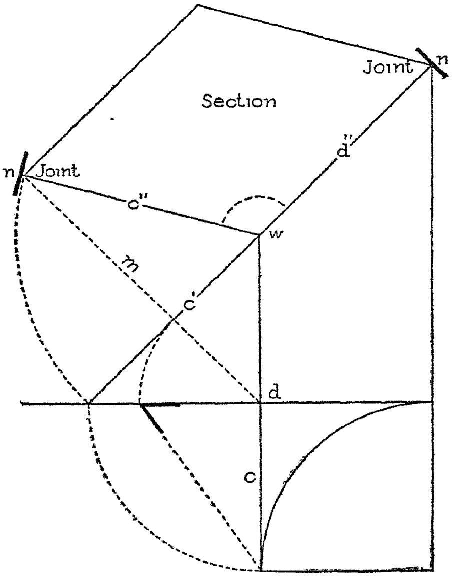


Fig. 92. Finding Angle between Tangents.

Fig. 93 is another view of these tangents in position placed over and above the plan tangents of the well-hole. It will be observed that this figure is made up of Figs. 88 and 91 combined. Fig. 88, as here presented, is shown to connect with a level-landing rail at *a*. The joint having been made square to the level tangent, *a* will butt square to a square end of the level rail. The joint at *h* is shown to connect the two wreaths and is made square to the inclined tangent *m* of the lower wreath, and also square to the inclined tangent *c″* of the upper wreath; the two tangents, aligning, guarantee a square butt-joint. The upper joint is made square to the tangent *d″*, which is here shown to align with the rail of the connecting flight; the joint will consequently butt square to the end of the rail of the flight above.

The view given in this diagram is that of a wreath starting from a level landing, and winding around a well-hole, connecting the landing with a flight of stairs leading to a second story. It is presented to elucidate the use made of tangents to square the joints in wreath construction. The wreath is shown to be in two sections, one extending from the level-landing rail at *a* to a joint in the center of the well-hole at *h*, this section having one level tangent *a* and one inclined tangent *m*; the other section is shown to extend from *h* to *n*, where it is butt-jointed to the rail of the flight above.

This figure clearly shows that the joint at *a* of the bottom wreath—owing to the tangent *a* being level and therefore aligning with the level rail of the landing—will be a true butt-joint; and that the joint at *h*, which connects the two wreaths, will also be a true butt-joint, owing to it being made square to the tangent *m* of the bottom wreath and to the tangent *c″* of the upper wreath, both tangents having the same inclination; also the joint at *n* will butt square to the rail of the flight above,

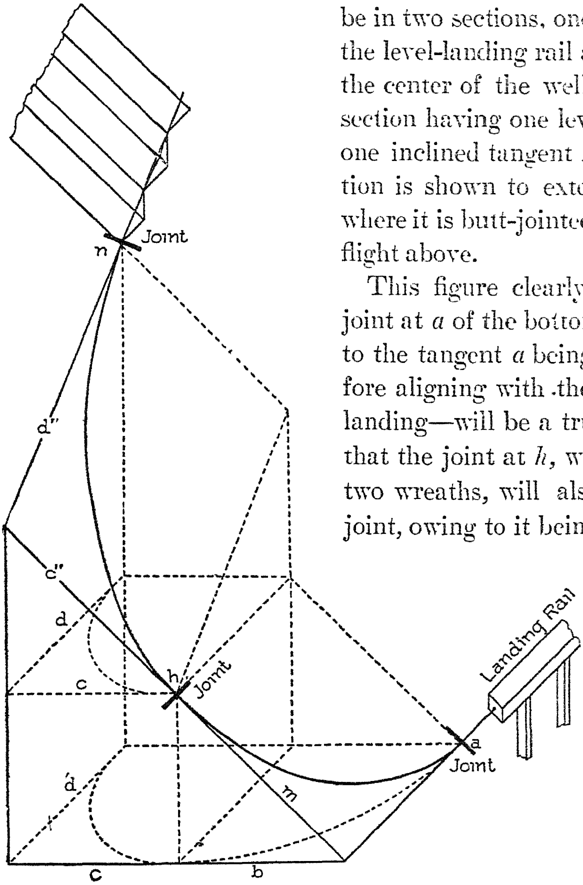


Fig 93 Laying Out Line of Wreath to Start from Level-Landing Rail, Wind around Well-Hole, and Connect at Landing with Flight to Upper Story.

owing to it being made square to the tangent d'', which is shown to have the same inclination as the rail of the flight adjoining.

As previously stated, the use made of tangents is to square the joints of the wreaths; and in this diagram it is clearly shown that the way they can be made of use is by giving each tangent its true direction. How to find the true direction, or the angle between the tangents *a* and *m* shown in this diagram, was demonstrated in Fig. 89; and how to find the direction of the tangents c'' and d'' was shown in Fig. 92.

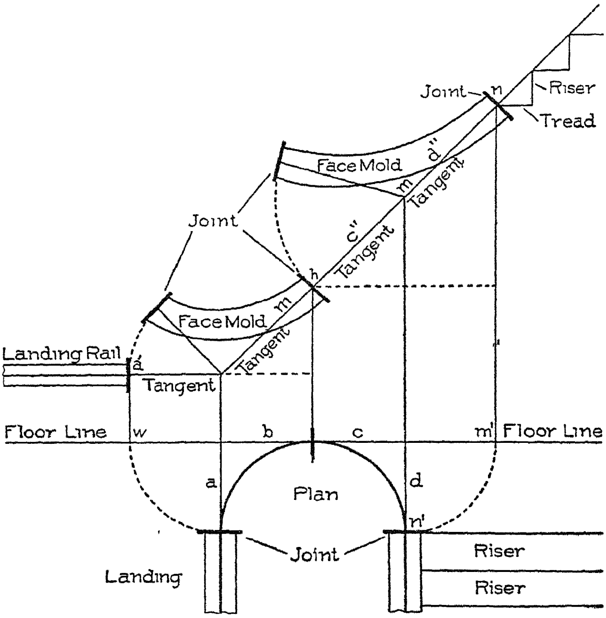
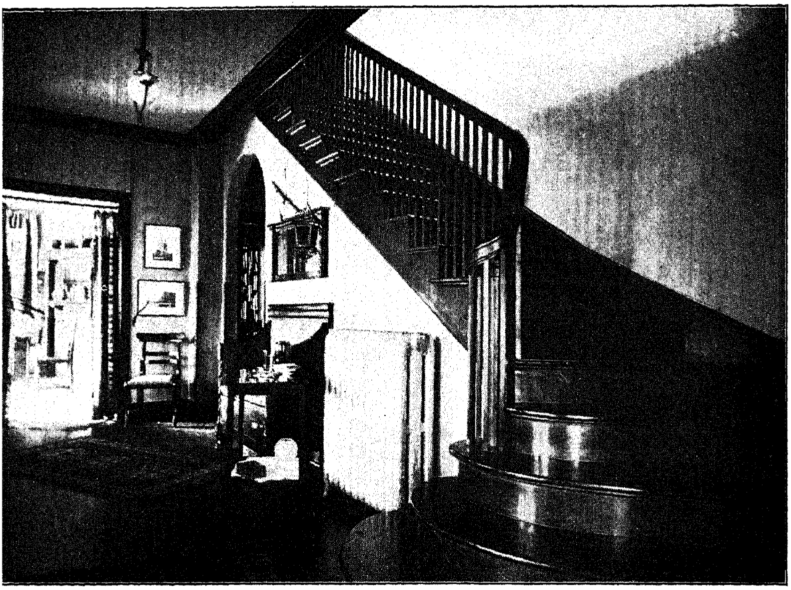
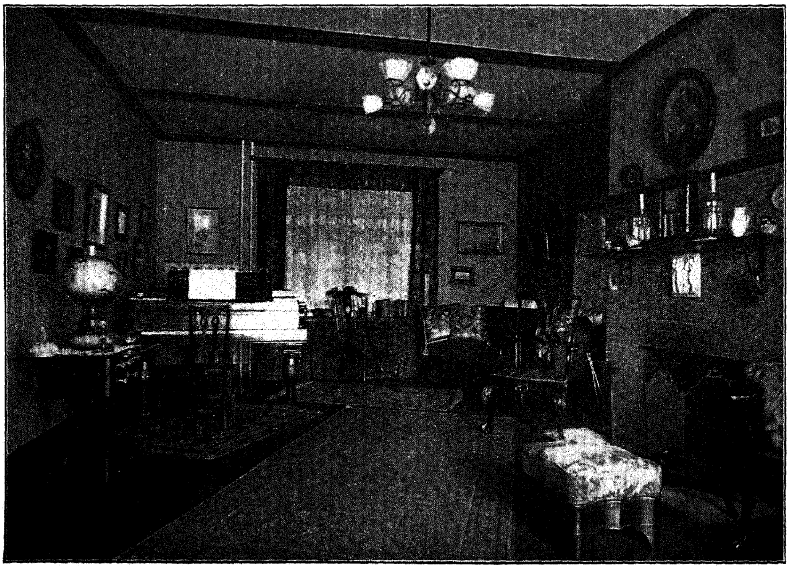


Fig 94. Tangents Unfolded to Find Their Inclination.

Fig. 94 is presented to help further toward an understanding of the tangents. In this diagram they are unfolded; that is, they are stretched out for the purpose of finding the inclination of each one over and above the plan tangents. The side plan tangent *a* is shown stretched out to the floor line, and its elevation a' is a level line. The side plan tangent *d* is also stretched out to the floor line, as shown by the arc n' m'. By this process the plan tangents are now in one straight line on the floor line, as shown from *w* to m'. Upon each one, erect a perpendicular line as shown, and from m' measure to *n*, the height the wreath is to ascend around the well-hole. In



STAIR HALL OF HOUSE IN URBANA, ILL.



LIVING ROOM OF HOUSE IN URBANA, ILL.
White & Temple, Architects, University of Illinois
For Exterior and Plans, See Page 266.

practice, the number of risers in the well-hole will determine this height.

Now, from point *n*, draw a few treads and risers as shown; and along the nosing of the steps, draw the pitch-line, continue this line over the tangents *d″*, *c″*, and *m*, down to where it connects with the bot om level tangent, as shown. This gives the pitch or inclination to the tangents over and above the well-hole. The same line is shown in Fig. 93, folded around the well-hole, from *n*, where it connects with the flight at the upper end of the well-hole, to *a*, where it connects with the level-landing rail at the bottom of the well-hole. It will be observed that the upper portion, from joint *n* to joint *h*, over the tangents *c″* and *d″*, coincides with the pitch-line of the same tangents as presented in Fig. 92, where they are used to find the true angle between the tangents as it is required on the face-mould to square the joints of the wreath at *h*.

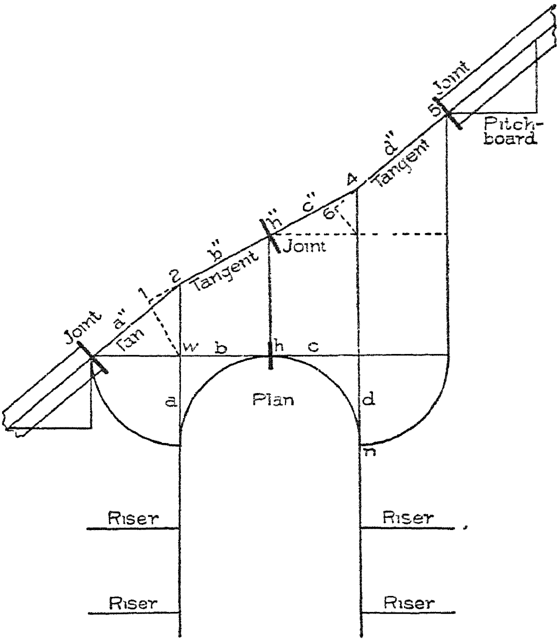


Fig. 93. Well-Hole Connecting Two Flights, with Two Wreath-Pieces, Each Containing Portions of Unequal Pitch.

In Fig. 89 the same pitch is shown given to tangent *m* as in Fig. 94; and in both figures the pitch is shown to be the same as that over and above the upper connecting tangents *c″* and *d″*, which is a necessary condition where a joint, as shown at *h* in Figs. 93 and 94, is to connect two pieces of wreath as in this example.

In Fig. 94 are shown the two face-moulds for the wreaths, placed upon the pitch-line of the tangents over the well-hole. The angles between the tangents of the face-moulds have been found in this figure by the same method as in Figs. 89 and 92, which, if compared with the present figure, will be found to correspond, excepting only the curves of the face-moulds in Fig. 94.

The foregoing explanation of the tangents will give the student a fairly good idea of the use made of tangents in wreath construction. The treatment, however, would not be complete if left off at this point, as it shows how to handle tangents under only two conditions—namely, first, when one tangent inclines and the other is level, as at *a* and *m;* second, when both tangents incline, as shown at *c″* and *d″*.

In Fig. 95 is shown a well-hole connecting two flights, where two portions of unequal pitch occur in both pieces of wreath. The first piece over the tangents *a* and *b* is shown to extend from the square end of the straight rail of the bottom flight, to the joint in the center of the well-hole, the bottom tangent *a″* in this wreath inclining more than the upper tangent *b″*. The other piece of wreath is shown to connect with the bottom one at the joint *h″* in the center of the well-hole, and to extend over tangents *c″* and *d″* to connect with the rail of the upper flight. The relative inclination of the two tangents in this wreath, is the reverse of that of the two tangents of the lower wreath. In the lower piece, the bottom tangent *a″*, as previously stated, inclines considerably more than does the upper tangent *b″*; while in the upper piece, the bottom tangent *c″* inclines considerably less than the upper tangent *d″*.

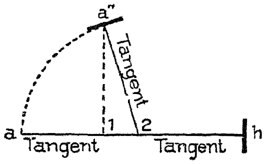


Fig. 96 Finding Angle between Tangents for Bottom Wreath of Fig. 95.

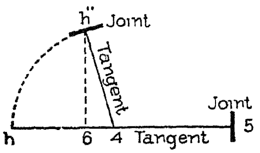


Fig 97. Finding Angle between Tangents for Upper Wreath of Fig 95.

The question may arise: What causes this? Is it for variation in the inclination of the tangents over the well-hole? It is simply owing to the tangents being used in handrailing to square the joints.

The inclination of the bottom tangent *a″* of the bottom wreath is clearly shown in the diagram to be determined by the inclination of the bottom flight. The joint at a'' is made square to both the straight rail of the flight and to the bottom tangent of the wreath; the rail and tangent, therefore, must be equally inclined, otherwise the joint will not be a true butt-joint. The same remarks apply to the joint at 5, where the upper wreath is shown jointed to the straight rail of the upper flight. In this case, tangent d'' must be fixed to incline conformably to the inclination of the upper rail; otherwise the joint at 5 will not be a true butt-joint.

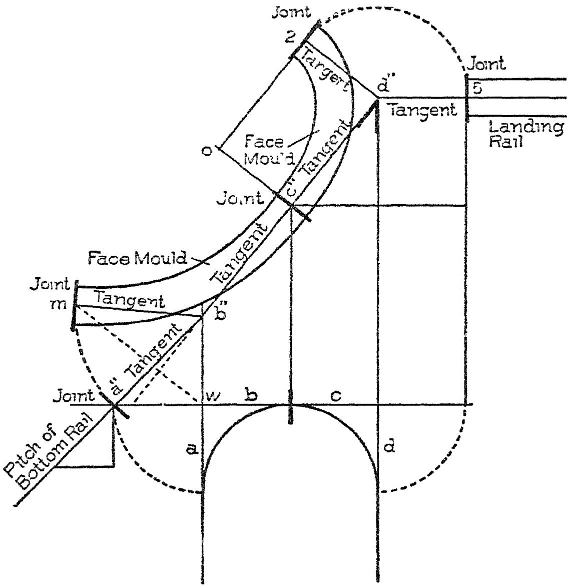


Fig. 98. Diagram of Tangents and Face-Mould for Stair with Well-Hole at Upper Landing

The same principle is applied in determining the pitch or inclination over the crown tangents b'' and c''. Owing to the necessity of jointing the two wreaths, as shown at *h*, these two tangents must have the same inclination, and therefore must be fixed, as shown from 2 to 4, over the crown of the well-hole.

The tangents as here presented are those of the elevation, not of the face-mould. Tangent a'' is the elevation of the side plan tangent *a*; tangents b'' and c'' are shown to be the elevations of the plan tangents *b* and *c;* so, also, is the tangent d'' the elevation of the side plan tangent *d*.

If this diagram were folded, as Fig. 94 was shown to be in Fig. 93, the tangents of the elevation—namely, a'', b'', c'', d''—would stand over and above the plan tangents *a*, *b*, *c*, *d* of the well-hole. In practical work, this diagram must be drawn full size. It gives the correct length to each tangent as required on the face-mould, and furnishes also the data for the lay-out of the mould.

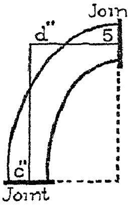


Fig 99 Drawing Mould when One Tangent is Level and One Inclined over Right-Angled Plan.

Fig. 96 shows how to find the angle between the tangents of the face-mould for the bottom wreath, which, as shown in Fig. 95, is to span over the first plan quadrant *a b*. The elevation tangents *a''* and *b''*, as shown, will be the tangents of the mould. To find the angle between the tangents, draw the line *a h* in Fig .96; and from *a*, measure to 2 the length of the bottom tangent *a''* in Fig. 95; the length from 2 to *h*, Fig. 96, will equal the length of the upper tangent *b''*, Fig. 95.

From 2 to 1, measure a distance equal to 2-1 in Fig. 95, the latter being found by dropping a perpendicular from *w* to meet the tangent *b''* extended. Upon 1, erect a perpendicular line; and placing the dividers on 2, extend to *a;* turn over to the perpendicular at *a''*; connect this point with 2, and the line will be the bottom tangent as required on the face-mould. The upper tangent will be the line 2-*h*, and the angle between the two lines is shown at 2. Make the joint at *h* square to 2-*h*, and at *a''* square to *a''*-2.

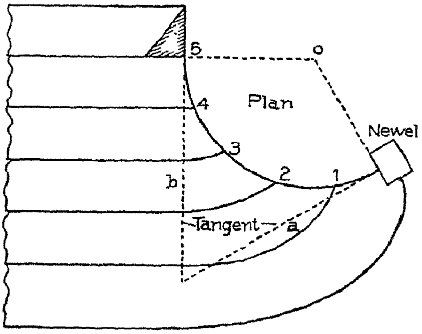


Fig. 100. Plan of Curved Steps and Stringer at Bottom of Stair.

The mould as it appears in Fig. 96 is complete, except the curve, which is comparatively a small matter to put on, as will be shown further on. The main thing is to find the angle between the tangents, which is shown at 2, to give them the direction to square the joints.

In Fig. 97 is shown how to find the angle between the tangents *c''* and *d''* shown in Fig. 95, as required on the face-mould. On the line *h*–5, make *h*–4 equal to the length of the bottom tangent of the wreath, as shown at *h''*–4 in Fig. 95; and 4–5 equal to the length of the upper tangent *d''*. Measure from 4 the distance shown at 4–6 in Fig 95, and place it from 4 to 6 as shown in Fig. 97; upon 6 erect a perpendicular line Now place the dividers on 4; extend to h; turn over to cut the perpendicular in h''; connect this point with 4, and the angle shown at 4 will be the angle required to square the joints of the wreath as shown at h'' and 5, where the joint at 5 is shown drawn square to the line 4–5, and the joint at h'' square to the line 4 h''.

Fig. 98 is a diagram of tangents and face-mould for a stairway having a well-hole at the top landing. The tangents in this example will be two equally inclined tangents for the bottom wreath; and for the top wreath, one inclined and one level, the latter aligning with the level rail of the landing.

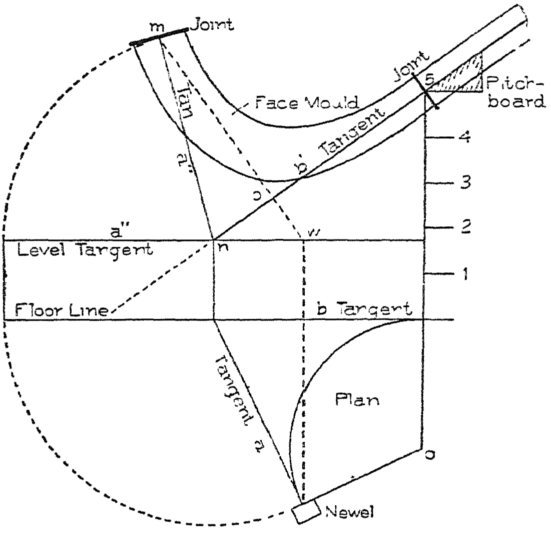


Fig. 101. Finding Angle between Tangents for Squaring Joints of Ramped Wreath

The face-mould, as here presented, will further help toward an understanding of the lay-out of face-moulds as shown in Figs. 96 and 97. It will be observed that the pitch of the bottom rail is continued from a'' to b'', a condition caused by the necessity of jointing the wreath to the end of the straight rail at a'', the joint being made square to both the straight rail and the bottom tangent a''. From b'' a line is drawn to d'', which is a fixed point determined by the number of risers in the well-hole. From point d'', the level tangent d'' 5 is drawn in line with the level rail of the landing; thus the pitch-line of the tangents over the well-hole is found, and, as was shown in the explanation of Fig. 95, the tangents as here presented will be those required on the face-mould to square the joints of the wreath.

In Fig. 98 the tangents of the face-mould for the bottom wreath are shown to be a'' and b''. To place tangent a'' in position on the face-mould, it is revolved, as shown by the arc, to m, cutting a line previously drawn from *w* square to the tangent *b″* extended. Then, by connecting *m* to *b″*, the bottom tangent is placed in position on the face-mould. The joint at *m* is to be made square to it; and the joint at *c*, the other end of the mould, is to be made square to the tangent *b″*.

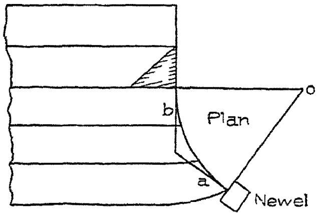


Fig. 102. Bottom Steps with Obtuse-Angle Plan.

The upper piece of wreath in this example is shown to have tangent *c″* inclining, the inclination being the same as that of the upper tangent *b″* of the bottom wreath, so that the joint at *c″*, when made square to both tangents, will butt square when put together. The tangent *d″* is shown to be level, so that the joint at 5, when squared with it, will butt square with the square end of the level-landing rail. The level tangent is shown revolved to its position on the face-mould, as from 5 to 2. In this last position, it will be observed that its angle with the inclined tangent *c″* is a right angle; and it should be remembered that in every similar case where one tangent inclines and one is level over a square-angle plan tangent, the angle between the two tangents will be a right angle on the face-mould. A knowledge of this principle will enable the student to draw the mould for this wreath, as shown in Fig. 99, by merely drawing two lines perpendicular to each other, as *d″* 5 and *d″ c″*, equal respectively to the level tangent *d″* 5 and the inclined tangent *c″* in Fig. 98. The joint at 5 is to be made square to *d″* 5; and that at *c″*, to *d″ c″*. Comparing this figure with the face-mould as shown for the upper wreath in Fig. 98, it will be observed that both are alike.

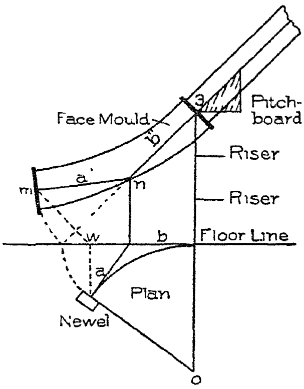


Fig. 103 Developing Face-Mould, Obtuse-Angle Plan.

In practical work the stair-builder is often called upon to deal with cases in which the conditions of tangents differ from all the examples thus far given. An instance of this sort is shown in Fig. 100, in which the angles between the tangents on the plan are acute.

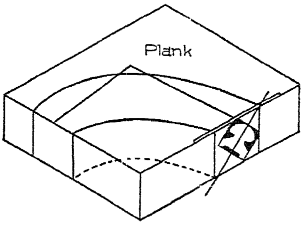


Fig 104. Cutting Wreath from Plank

In all the preceding examples, the tangents on the plan were at right angles; that is, they were square to one another.

Fig. 100 is a plan of a few curved steps placed at the bottom of a stairway with a curved stringer, which is struck from a center *o*. The plan tangents *a* and *b* are shown to form an acute angle with each other. The rail above a plan of this design is usually ramped at the bottom end, where it intersects the newel post, and, when so treated, the bottom tangent *a* will have to be level.

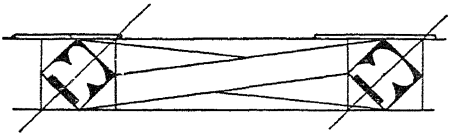


Fig. 105 Wreath Twisted, Ready to be Moulded.

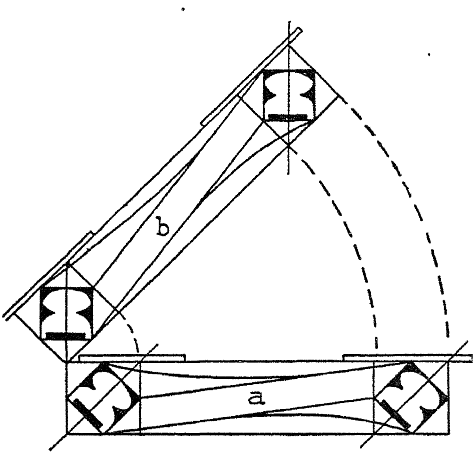


Fig. 106. Twisted Wreath Raised to Position, with Sides Plumb

In Fig. 101 is shown how to find the angle between the tangents on the face-mould that gives them the correct direction for squaring the joints of the wreath when it is determined to have it ramped. This figure must be drawn full size. Usually an ordinary drawing-board will answer the purpose. Upon the board, reproduce the plan of the tangents and curve of the center line of rail as shown in Fig. 100. Measure the height of 5 risers, as shown in Fig. 101, from the floor line to 5; and draw the pitch of the flight adjoining the wreath, from 5 to the floor line. From the newel, draw the dotted line to *w*, square to the floor line; from *w*, draw the line *w m*, square to the pitch-line b''. Now take the length of the bottom level tangent on a trammel, or on dividers if large enough, and extend it from *n* to *m*, cutting the line drawn previously from

w, at m. Connect m to n as shown by the line a''. The intersection of this line with b'' determines the angle between the two tangents a'' and b'' of the face-mould, which gives them the correct direction as required on the face-mould for squaring the joints. The joint at m is made square to tangent a''; and the joint at 5, to tangent b''.

In Fig. 102 is presented an example of a few steps at the bottom of a stairway in which the tangents of the plan form an obtuse angle with each other. The curve of the central line of the rail in this case will be less than a quadrant, and, as shown, is struck from the center o, the curve covering the three first steps from the newel to the springing.

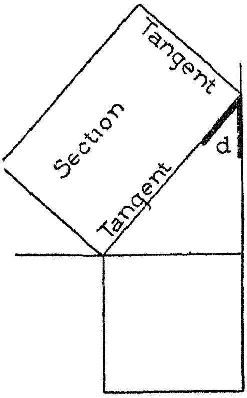


Fig 107. Finding Bevel, Bottom Tangent Inclined, Top One Level.

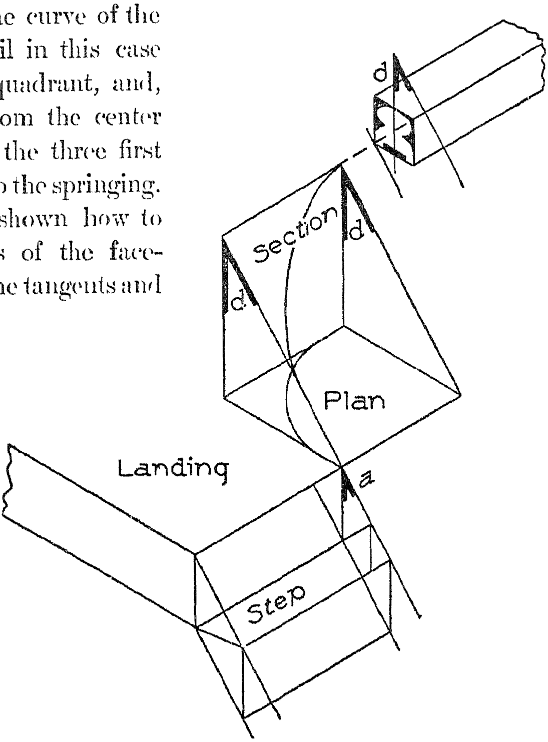


Fig. 108. Application of Bevels in Fitting Wreath to Rail.

In Fig. 103 is shown how to develop the tangents of the face-mould. Reproduce the tangents and curve of the plan in full size. Fix point 3 at a height equal to 3 risers from the floor line; at this point place the pitch-board of the flight to determine the pitch over the curve as shown from 3 through b'' to the floor line. From the newel, draw a line to w, square to the floor line; and from w, square to the pitch-line b'', draw the line $w\ m$; connect m to n. This last line is the development of the bottom plan tangent a; and the line b'' is the development of the plan tangent *b;* and the angle between the two lines *a''* and *b''* will give each line its true direction as required on the face-mould for squaring the joints of the wreath, as shown at *m* to connect square with the newel, and at 3 to connect square to the rail of the connecting flight.

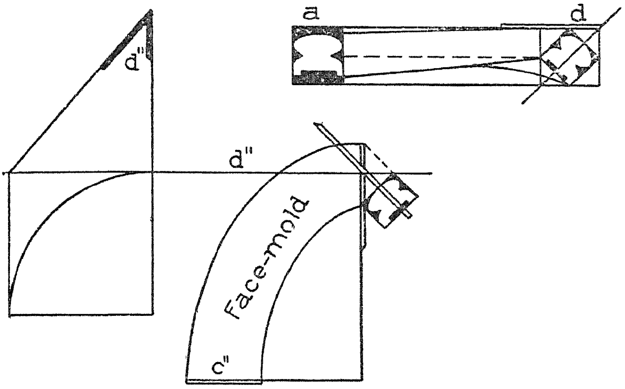


Fig 109 Face Mould and Bevel for Wreath, Bottom Tangent Level, Top One Inclined

The wreath in this example follows the nosing line of the steps without being ramped as it was in the examples shown in Figs. 100 and 101. In those figures the bottom tangent *a* was level, while in Fig. 103 it inclines equal to the pitch of the upper tangent *b''* and of the flight adjoining. In other words, the method shown in Fig. 101 is applied to a construction in which the wreath is ramped; while in Fig. 103 the method is applicable to a wreath following the nosing line all along the curve to the newel.

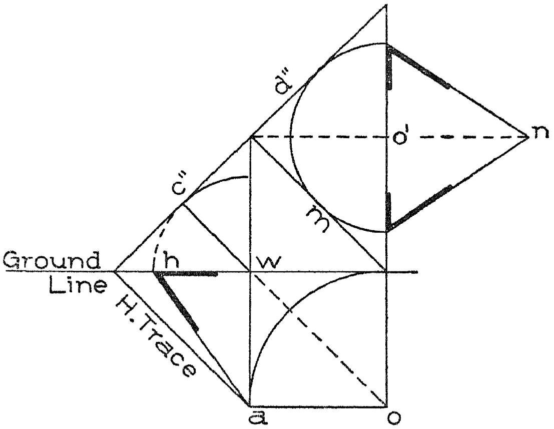


Fig. 110 Finding Bevels for Wreath with Two Equally Inclined Tangents.

The stair-builder is supposed to know how to construct a wreath under both conditions, as the conditions are usually determined by the Architect.

The foregoing examples cover all conditions of tangents that are likely to turn up in practice, and, if clearly understood, will enable the student to lay out the face-moulds for all kinds of curves.

Bevels to Square the Wreaths. The next process in the construction of a wreath that the handrailer will be called upon to perform, is to find the bevels that will, by being applied to each end of it, give the correct angle to *square* or *twist* it when winding around the well-hole from one flight to another flight, or from a flight to a landing, as the case may be.

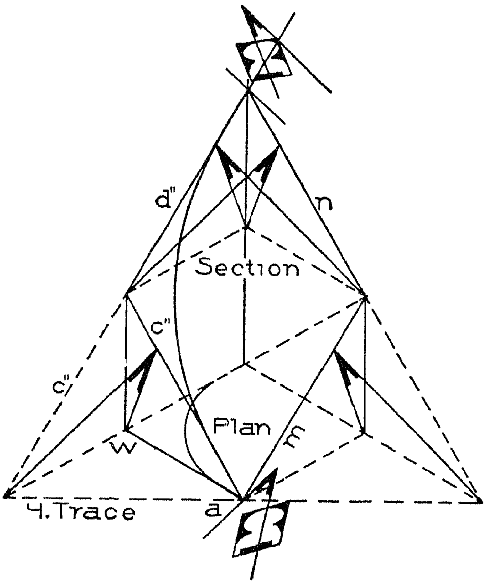


Fig 111 Application of Bevels to Wreath Ascending on Plane Inclined Equally in Two Directions

The wreath is first cut from the plank square to its surface as shown in Fig. 104. After the application of the bevels, it is twisted, as shown in Fig. 105, ready to be moulded; and when in position, ascending from one end of the curve to the other end, over the inclined plane of the section around the well-hole, its sides will be plumb, as shown in Fig. 106 at *b*. In this figure, as also in Fig. 105, the wreath *a* lies in a horizontal position in which its sides appear to be out of plumb as much as the bevels

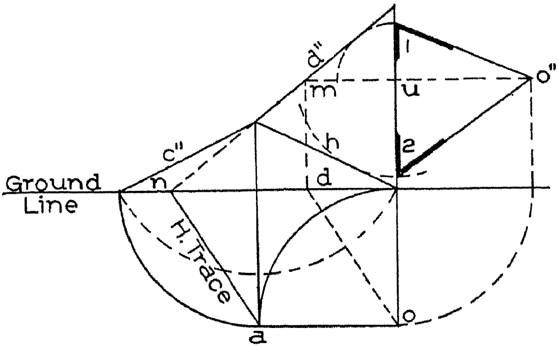


Fig 112 Finding Bevel Where Upper Tangent Inclines More Than Lower One.

are out of plumb. In the upper part of the figure, the wreath *b* is shown placed in its position upon the plane of the section, where its sides are seen to be plumb. It is evident, as shown in the relative position of the wreath in this figure, that, if the bevel is the correct angle of the plane of the section whereon the wreath *b* rests in its ascent over the well-hole, the wreath will in that case have its sides plumb all along when in position. It is for this purpose that the bevels are needed.

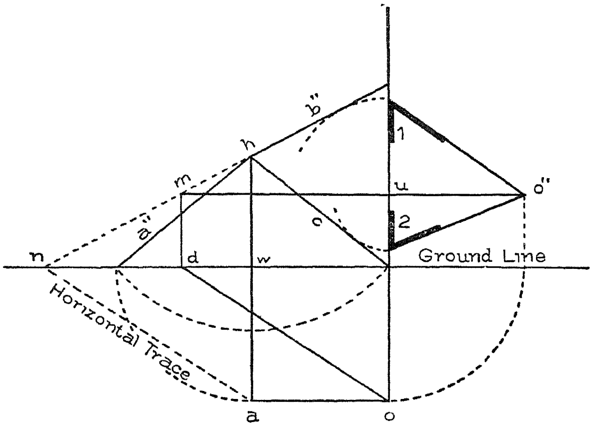


Fig 113 Finding Bevel Where Upper Tangent Inclines Less Than Lower One

A method of finding the bevels for *all wreaths* (which is considered rather difficult) will now be explained:

First Case. In Fig. 107 is shown a case where the bottom tangent of a wreath is inclining, and the top one level, similar to the top wreath shown in Fig. 98. It has already been noted that the plane of the section for this kind of wreath inclines to one side only; therefore one bevel only will be required to square it, which is shown at *d*, Fig. 107. A view of this plane is given in Fig. 108; and the bevel *d*, as there shown, indicates the angle of the inclination, which also is the bevel required to square the end *d* of the wreath. The bevel is shown applied to the end of the landing rail in exactly the same manner in which it is to be applied to the end of the wreath. The true bevel for this wreath is found at the upper angle of the pitch-board. At the end *a*, as already stated, no bevel is required, owing to the plane inclining in one direction only. Fig. 109 shows a face-mould and bevel for a wreath with the bottom tangent level and the top tangent inclining, such as the piece at the bottom connecting with the landing rail in Fig. 94.

Second Case. It may be required to find the bevels for a wreath having two equally inclined tangents. An example of this kind also is shown in Fig. 94, where both the tangents c'' and d'' of the upper wreath incline equally. Two bevels are required in this case, because the plane of the section is inclined in two directions; but, owing to the inclinations being alike, it follows that the two will be the same. They are to be applied to both ends of the wreath, and, as shown in Fig. 105, in the same direction—namely, toward the inside of the wreath for the bottom end, and toward the outside for the upper end.

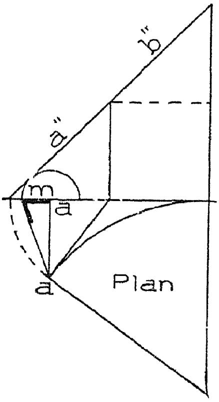


Fig. 114. Finding Bevel Where Tangents Incline Equally over Obtuse-Angle Plan.

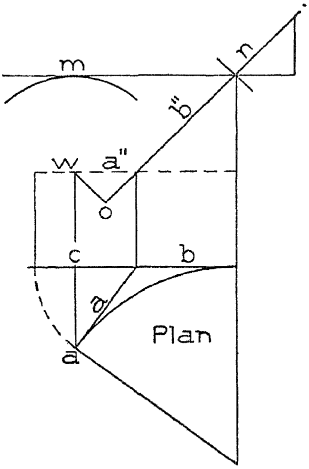


Fig. 115. Same Plan as in Fig. 114, but with Bottom Tangent Level.

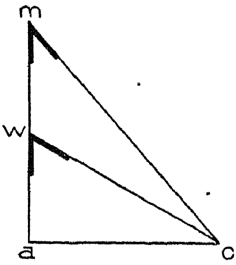


Fig. 116. Finding Bevels for Wreath of Fig. 115.

In Fig. 110 the method of finding the bevels is shown. A line is drawn from w to c'', square to the pitch of the tangents, and turned over to the ground line at h, which point is connected to a as shown. The bevel is at h. To show that equal tangents have equal bevels, the line m is drawn, having the same inclination as the bottom tangent c'', but in another direction. Place the dividers on o', and turn to touch the lines d'' and m, as shown by the semicircle. The line from o' to n is equal to the side plan tangent *w a*, and both the bevels here shown are equal to the one already found. They represent the angle of inclination of the plane whereon the wreath ascends, a view of which is given in Fig. 111, where the plane is shown to incline equally in two directions. At both ends is shown a section of a rail; and the bevels are applied to show how by means of them, the wreath is *squared* or *twisted* when winding around the well-hole and ascending upon the plane of the section. The view given in this figure will enable the student to understand the nature of the bevels found in Fig. 110 for a wreath having two equally inclined tangents; also for all other wreaths of equally inclined tangents, in that every wreath in such case is assumed to rest upon an inclined plane in its ascent over the well-hole, the bevel in every case being the angle of the inclined plane.

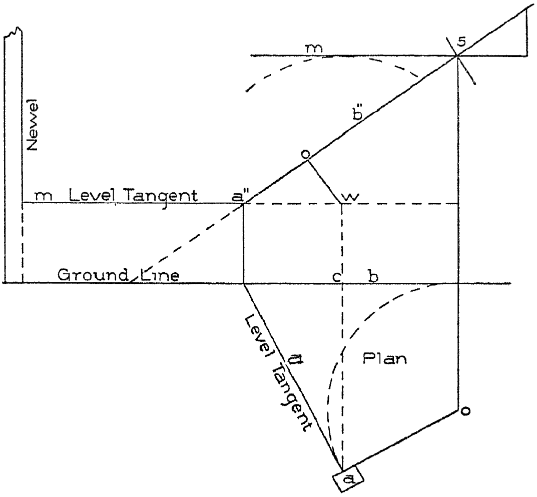


Fig 117 Upper Tangent Inclined, Lower Tangent Level, Over Acute-Angle Plan

Third Case. In this example, two unequal tangents are given, the upper tangent inclining more than the bottom one. The method shown in Fig 110 to find the bevels for a wreath with two equal tangents, is applicable to all conditions of variation in the inclination of the tangents. In Fig. 112 is shown a case where the upper tangent *d''* inclines more than the bottom one *c''*. The method in all cases is to continue the line of the upper tangent *d''*, Fig. 112, to the ground line as shown at *n*; from *n*, draw a line to *a*, which will be the horizontal trace of the plane. Now, from *o*, draw a line parallel to *a n*, as shown from *o* to *d*, upon *d*, erect a perpendicular line to cut the tangent *d''*, as shown, at *m*; and draw the line *m u o''*. Make *u o''* equal to the length of the plan tangent as shown by the arc from *o*. Put one leg of the dividers on u; extend to touch the upper tangent d'', and turn over to 1; connect 1 to o''; the bevel at 1 is to be applied to tangent d''. Again place the dividers on u; extend to the line h, and turn over to 2 as shown; connect 2 to o'', and the bevel shown at 2 will be the one to apply to the bottom tangent e''. It will be observed that the line h represents the bottom tangent. It is the same length and has the same inclination. An example of this kind of wreath was shown in Fig. 95, where the upper tangent d'' is shown to incline more than the bottom tangent e'' in the top piece extending from h'' to 5. Bevel 1, found in Fig 112, is the real bevel for the end 5; and bevel 2, for the end h'' of the wreath shown from h'' to 5 in Fig. 95.

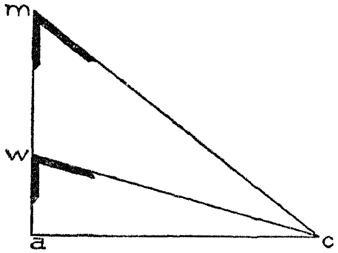


Fig. 118. Finding Bevels for Wreath of Plan, Fig 117.

Fourth Case. In Fig. 113 is shown how to find the bevels for a wreath when the upper tangent inclines less than the bottom tangent. This example is the reverse of the preceding one; it is the condition of tangents found in the bottom piece of wreath shown in Fig. 95. To find the bevel, continue the upper tangent b'' to the ground line, as shown at n; connect n to a, which will be the horizontal trace of the plane. From o, draw a line parallel to n a, as shown from o to d; upon d, erect a perpendicular line to cut the continued portion of the upper tangent b'' in m; from m, draw the line m u o'' across as shown. Now place the dividers on u; extend to touch the upper tangent, and turn over to 1; connect 1 to o''; the bevel at 1 will be the one to apply to the tangent b'' at h, where the two wreaths are shown connected in Fig. 95. Again place the dividers on u; extend to touch the line e; turn over to 2; connect 2 to o''; the bevel at 2 is to be applied to the bottom tangent a'' at the joint where it is shown to connect with the rail of the flight.

Fifth Case. In this case we have two equally inclined tangents over an obtuse-angle plan. In Fig. 102 is shown a plan of this kind; and in Fig. 103, the development of the face-mould.

In Fig. 114 is shown how to find the bevel. From a, draw a line to a', square to the ground line. Place the dividers on a'; extend to touch the pitch of tangents, and turn over as shown to *m;* connect *m* to *a.* The bevel at *m* will be the only one required for this wreath, but it will have to be applied to both ends, owing to the two tangents being inclined.

Sixth Case. In this case we have one tangent inclining and one tangent level, over an acute-angle plan.

In Fig. 115 is shown the same plan as in Fig 114; but in this case the bottom tangent a'' is to be a level tangent. Probably this condition is the most commonly met with in wreath construction at the present time. A small curve is considered to add to the appearance of the stair and rail; and consequently it has become almost a "fad" to have a little curve or stretch-out at the bottom of the stairway, and in most cases the rail is ramped to intersect the newel at right angles instead of at the pitch of the flight. In such a case, the bottom tangent a'' will have to be a level tangent, as shown at a'' in Fig. 115, the pitch of the flight being over the plan tangent *b* only.

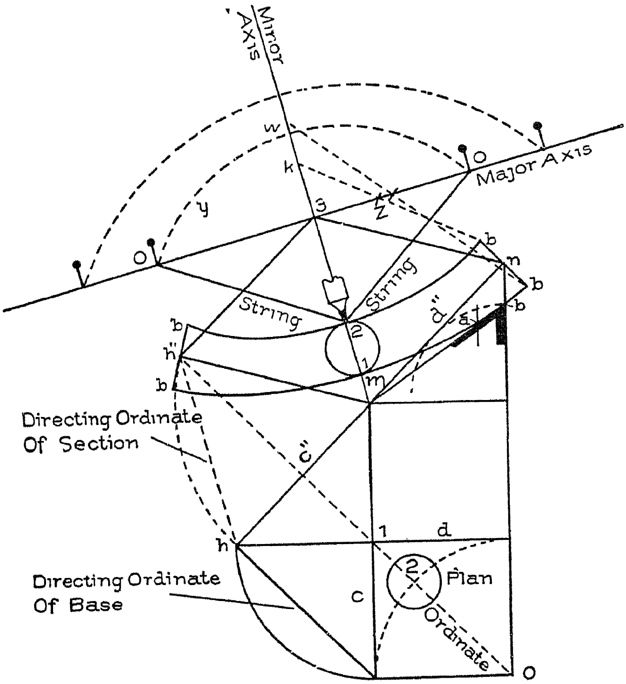


Fig 119. Laying Out Curves on Face-Mould with Pins and String

To find the bevels when tangent b'' inclines and tangent a'' is level, make *a c* in Fig. 116 equal to *a c* in Fig. 115. This line will be the base of the two bevels. Upon *a*, erect the line *a w m* at right angles to *a c*; make *a w* equal to *o w* in Fig 115; connect *w* and *c*; the bevel at *w* will be the one to apply to tangent b'' at *n* where the wreath is joined to the rail of the flight. Again, make *a m* in Fig. 116 equal the distance shown in Fig. 115 between *w* and *m*, which is the full height over which tangent b'' is inclined; connect *m* to *c* in Fig. 116, and at *m* is the bevel to be applied to the level tangent a''.

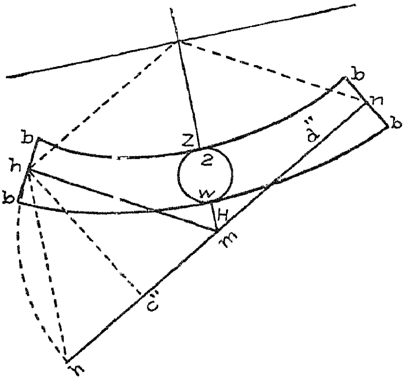


Fig 120. Simple Method of Drawing Curves on Face-Mould

Seventh Case. In this case, illustrated in Fig. 117, the upper tangent b'' is shown to incline, and the bottom tangent a'' to be level, over an acute-angle plan. The plan here is the same as that in Fig. 100, where a curve is shown to stretch out from the line of the straight stringer at the bottom of a flight to a newel, and is large enough to contain five treads, which are gracefully rounded to cut the curve of the central line of rail in 1, 2, 3, 4. This curve also may be used to connect a landing rail to a

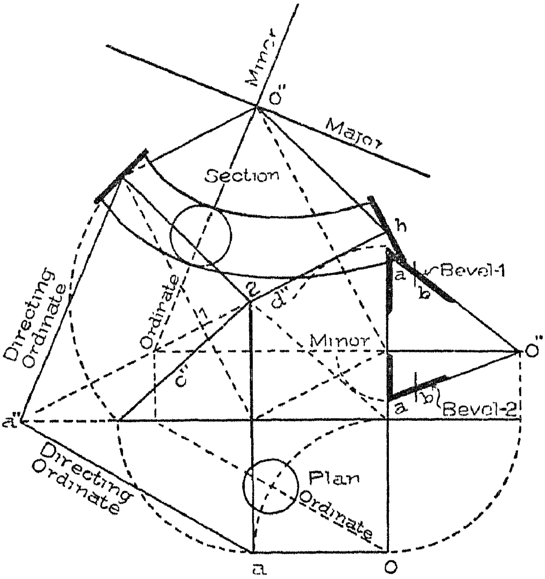
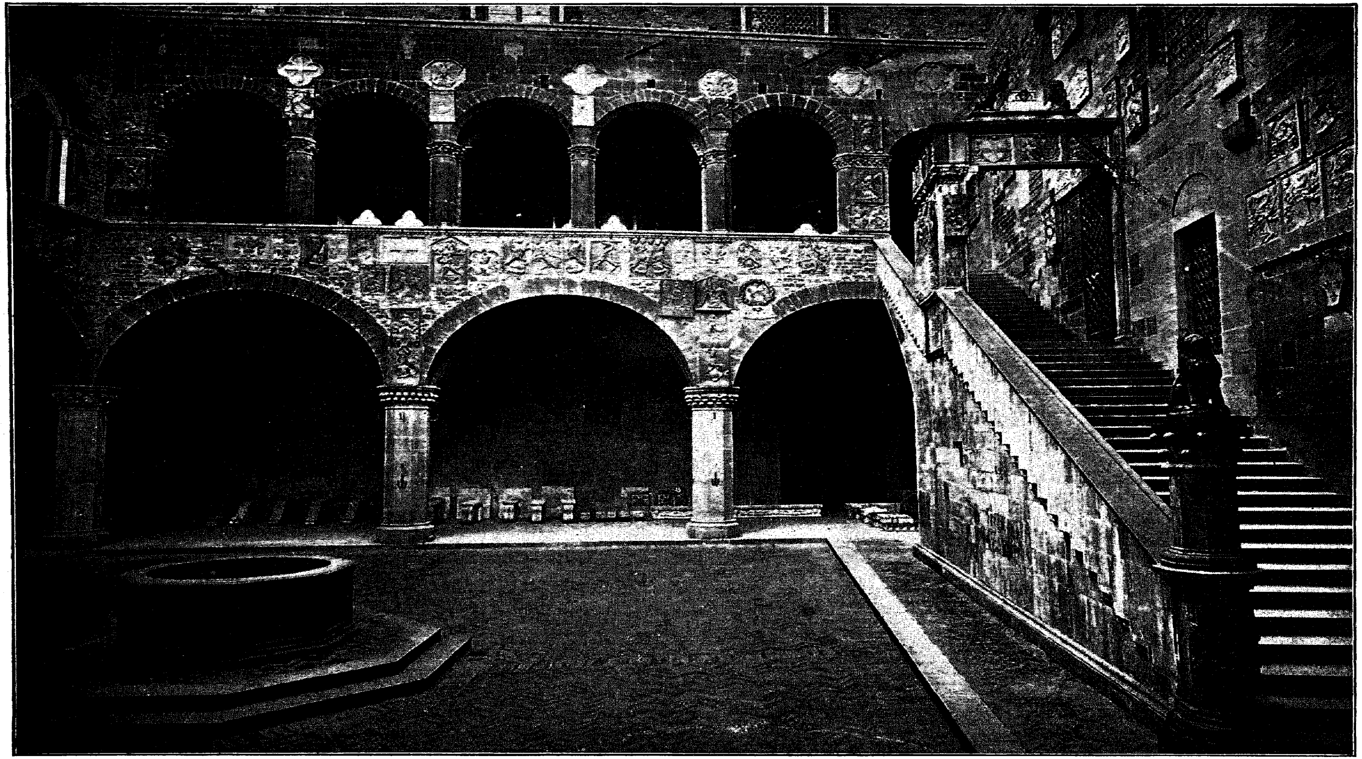


Fig. 121. Tangents, Bevels, Mould Curves, etc., from Bottom Wreath of Fig 95, in which Upper Tangent Inclines Less than Lower One.



COURTYARD AND STAIRCASE IN THE "BARGELLO," FLORENCE, ITALY
A Strong and Picturesque Treatment of a Courtyard.

flight, either at top or bottom, when the plan is acute-angled, as will be shown further on.

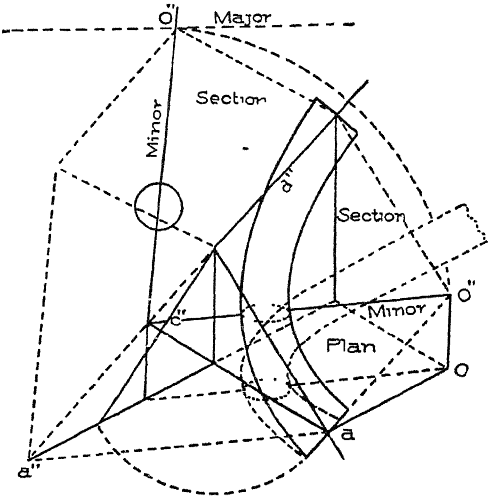


Fig. 122. Developed Section of Plane Inclining On equally in Two Directions

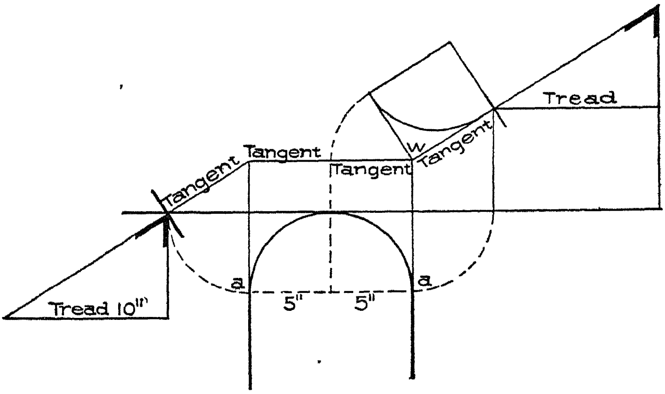


Fig 123 Arranging Risers around Well-Hole on Level-Landing Stair, with Radius of Central Line of Rail One-Half Width of Tread.

To find the bevels—for there will be two bevels necessary for this wreath, owing to one tangent b'' being inclined and the other tangent a'' being level—make *a c*, Fig. 118, equal to *a c* in Fig. 117, which is a line drawn square to the ground line from the newel and shown in all preceding figures to have been used for the base of a triangle containing the bevel. Make *a w* in Fig. 118 equal to *w o* in Fig. 117, which is a line drawn square to the inclined tangent b'' from *w;* connect *w* and *c* in Fig. 118. The bevel shown at *w* will be the one to be applied to the joint 5 on tangent b'', Fig. 117. Again, make *a m* in Fig. 118 equal to the distance shown in Fig. 117 between the line representing the level tangent and the line m' 5, which is the height that tangent b'' is shown to rise; connect m to c in Fig. 118; the bevel shown at m is to be applied to the end that intersects with the newel as shown at m in Fig. 117.

The wreath is shown developed in Fig. 101 for this case; so that, with Fig. 100 for plan, Fig. 101 for the development of the wreath, and Figs. 117 and 118 for finding the bevels, the method of handling any similar case in practical work can be found.

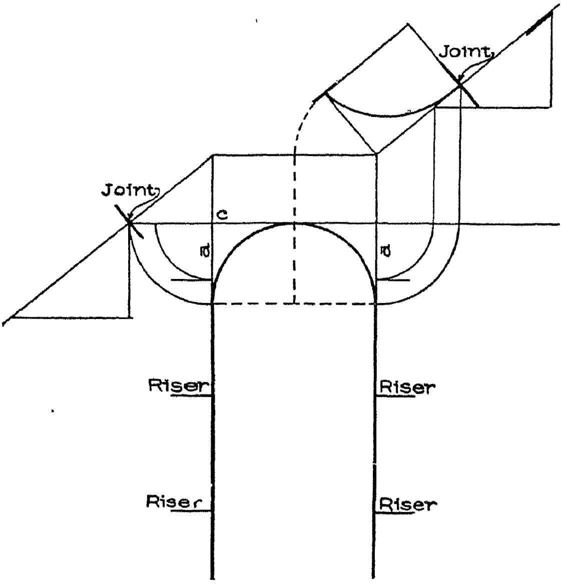


Fig. 124. Arrangement of Risers Around Well-Hole with Radius Larger Than One-Half Width of Tread.

How to Put the Curves on the Face-Mould. It has been shown how to find the angle between the tangents of the face-mould, and that the angle is for the purpose of squaring the joints at the ends of the wreath. In Fig. 119 is shown how to lay out the curves by means of pins and a string—a very common practice among stair-builders. In this example the face-mould has equal tangents as shown at c'' and d''. The angle between the two tangents is shown at m as it will be required on the face-mould. In this figure a line is drawn from m parallel to the line drawn from h, which is marked in the diagram as "Directing Ordinate of Section." The line drawn from m will contain the minor axes; and a line drawn through the corner of the section at 3 will contain the major axes of the ellipses that will constitute the curves of the mould.

The *major* is to be drawn square to the *minor*, as shown. Place, from point 3, the circle shown on the minor, at the same distance as the circle in the plan is fixed from the point o. The diameter of this circle indicates the width of the curve at this point. The width at each end is determined by the bevels. The distance *a b*, as shown

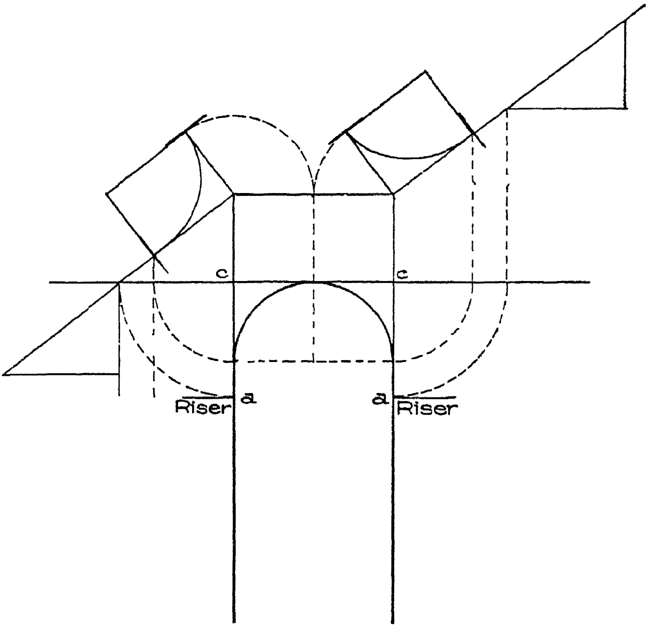


Fig. 125. Arrangement of Risers around Well-Hole, with Risers Spaced Full Width of Tread

upon the long edge of the bevel, is equal to $\frac{1}{2}$ the width of the mould, and is the hypotenuse of a right-angled triangle whose base is $\frac{1}{2}$ the width of the rail. By placing this dimension on each side of *n*, as shown at *b*

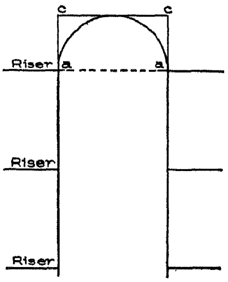


Fig 126. Plan of Stair Shown in Fig 123.

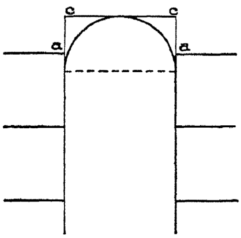


Fig. 127. Plan of Stair Shown in Fig. 124.

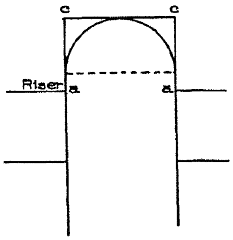


Fig. 128 Plan of Stair Shown in Fig. 125.

and *b*, and on each side of *h″* on the other end of the mould, as shown also at *b* and *b*, we obtain the points *b* 2 *b* on the inside of the curve, and the points *b* 1 *b* on the outside. It will now be necessary to find the elliptical curves that will contain these points; and before this can be done, the exact length of the *minor* and *major* axes respectively must be determined. The length of the minor axis for the inside curve will be the distance shown from 3 to 2; and its length for the outside will be the distance shown from 3 to 1.

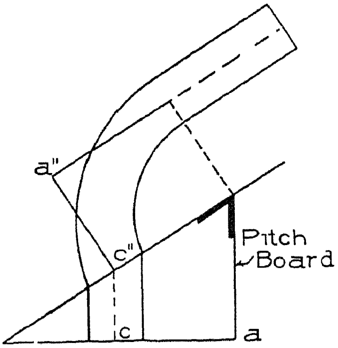


Fig. 129. Drawing Face-Mould for Wreath from Pitch-Board.

To find the length of the major axis for the inside, take the length of half the minor for the inside on the dividers: place one leg on *b*, extend to cut the major in *z*, continue to the minor as shown at *k*. The distance from *b* to *k* will be the length of the semi-major axis for the inside curve.

To draw the curve, the points or *foci* where the pins are to be fixed must be found on the major axis. To find these points, take the length of *b k* (which is, as previously found, the exact length of the semi-major for the inside curve) on the dividers; fix one leg at 2, and describe the arc *Y*, cutting the major where the pins are shown fixed, at *o* and *o*. Now take a piece of string long enough to form a

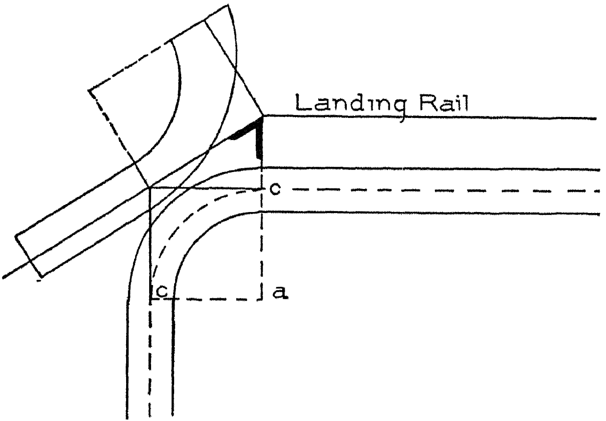


Fig. 130. Development of Face-Mould for Wreath Connecting Rail of Flight with Level-Landing Rail.

loop around the two and extending, when tight, to 2, where the pencil is placed; and, keeping the string tight, sweep the curve from *b* to *b*.

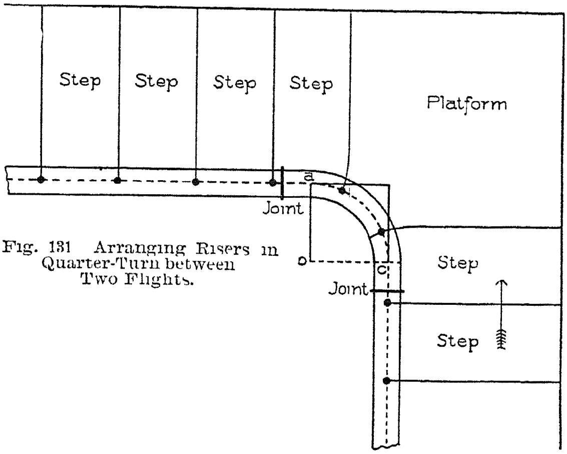


Fig. 131 Arranging Risers in Quarter-Turn between Two Flights.

The same method, for finding the *major* and *foci* for the outside curve, is shown in the diagram. The line drawn from *b* on the outside of the joint at *n*, to *w*, is the semi-major for the outside curve; and the

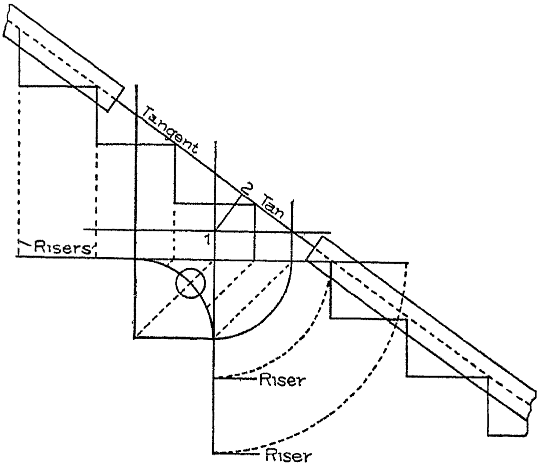


Fig 132 Arrangement of Risers around Quarter-Turn Giving Tangents Equal Pitch with Connecting Flight.

points where the outside pins are shown on the major will be the *foci*.

To draw the curves of the mould according to this method, which is a scientific one, may seem a complicated problem; but once it is understood, it becomes very simple. A simpler way to draw them, however, is shown in Fig. 120.

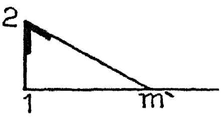


Fig 133. Finding Bevel for Wreath of Plan, Fig. 132.

The width on the minor and at each end will have to be determined by the method just explained in connection with Fig. 119. In Fig 120, the points *b* at the ends, and the points in which the circumference of the circle cuts the minor axis, will be points contained in the curves, as already explained. Now take a flexible lath; bend it to touch *b*, *z*, and *b* for the inside curve, and *b*, *w*, and *b* for the outside curve. This method is handy where the curve is comparatively flat, as in the example here shown; but where the mould has a sharp curvature, as in case of the one shown in Fig. 101, the method shown in Fig. 119 must be adhered to.

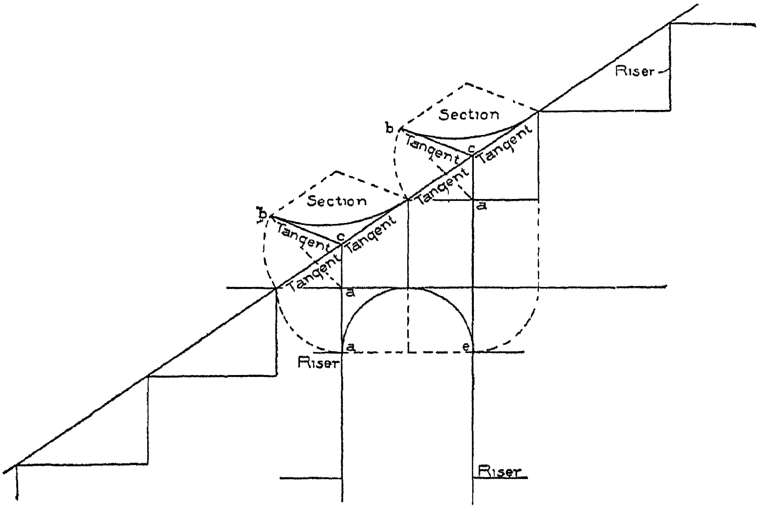


Fig. 134. Well-Hole with Riser in Center. Tangents of Face-Mould, and Central Line of Rail, Developed.

With a clear knowledge of the above two methods, the student will be able to put curves on any mould.

The mould shown in these two diagrams, Figs. 119 and 120, is for the upper wreath, extending from *h* to *n* in Fig. 94 A practical handrailer would draw only what is shown in Fig. 120. He would take the lengths of tangents from Fig. 94, and place them as shown at *h m* and *m n*. By comparing Fig. 120 with the tangents of the upper wreath in Fig. 94, it will be easy for the student to understand

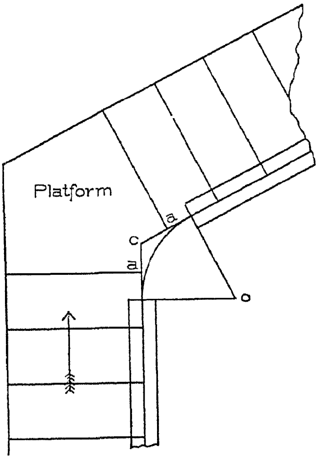


Fig. 135 Arrangement of Risers in Stair with Obtuse-Angle Plan

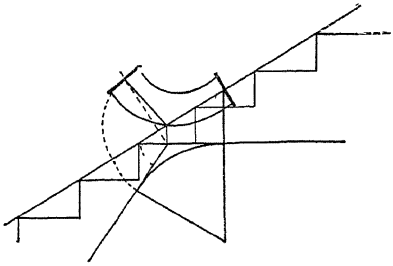


Fig 136 Arrangement of Risers in Obtuse-Angle Plan, Giving Equal Pitch over Tangents and Flights. Face-Mould Developed.

the remaining lines shown in Fig. 120. The bevels are shown applied to the mould in Fig. 105, to give it the twist. In Fig 106, is shown how, after the rail is twisted and placed in position over and above the quadrant *c d* in Fig. 94, its sides will be plumb.

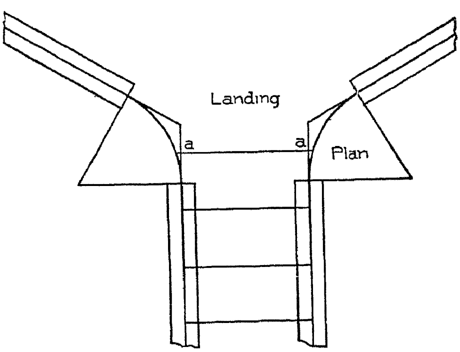


Fig. 137. Arrangement of Risers in Flight with Curve at Landing.

In Fig. 121 are shown the tangents taken from the bottom wreath in Fig. 95 It was shown how to develop the section and find the angle for the tangents in the face-mould, in Fig 113. The method shown in Fig. 119 for putting on the curves, would be the most suitable.

Fig. 121 is presented more for the purposes of study than as a method of construction. It contains all the lines made use of to find the developed section of a plane inclining unequally in two different directions, as shown in Fig. 122.

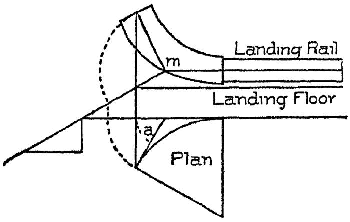


Fig. 138. Development of Face-Moulds for Plan, Fig 137

Arrangement of Risers in and around Well-Hole. An important matter in wreath construction is to have a knowledge of how to arrange the risers in and around a well-hole. A great deal of labor and material is saved through it; also a far better appearance to the finished rail may be secured.

In level-landing stairways, the easiest example is the one shown in Fig. 123, in which the radius of the central line of rail is made equal to one-half the width of a tread. In the diagram the radius is shown to be 5 inches, and the treads 10 inches. The risers are placed in the springing, as at *a* and *a*. The elevation of the tangents by this arrangement will be, as shown, one level and one inclined, for each piece of wreath. When in this position, there is no trouble in finding the angle of the tangent as required on the face-mould, owing to that angle, as in every such case, being a right angle, as shown at *w*; also no special bevel will have to be found, because the upper bevel of the pitch-board contains the angle required.

The same results are obtained in the example shown in Fig. 124, in which the radius of the well-hole is larger than half the width of a tread, by placing the riser *a* at a distance from *c* equal to half the width of a tread, instead of at the springing as in the preceding example.

In Fig. 125 is shown a case where the risers are placed at a distance from *c* equal to a full tread, the effect in respect to the tangents of the face-mould and bevel being the same as in the two preceding examples. In Fig. 126 is shown the plan of Fig. 123; in Fig. 127, the plan of Fig. 124; and in Fig. 128, the plan of Fig. 125. For the wreaths shown in all these figures, there will be no necessity of *springing* the plank, which is a term used in handrailing to denote the twisting of the wreath; and no other bevel than the one at the upper end of the pitch-board will be required. This type of wreath, also, is the one that is required at the top of a landing when the rail of the flight intersects with a level-landing rail.

In Fig. 129 is shown a very simple method of drawing the face-mould for this wreath from the pitch-board. Make *a c* equal to the radius of the plan central line of rail as shown at the curve in Fig. 130 From where line *c c''* cuts the long side of the pitch-board, the line *c'' a''* is drawn at right angles to the long edge, and is made equal to the length of the plan tangent *a c*, Fig. 130. The curve is drawn by means of pins and string or a trammel.

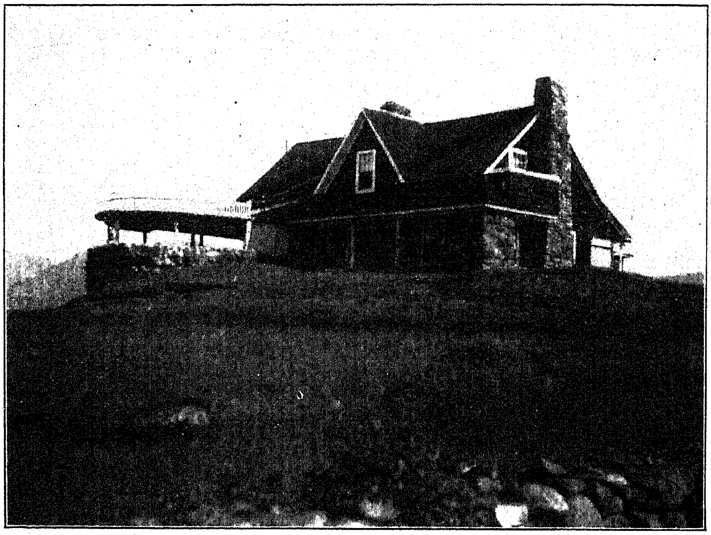
In Fig. 131 is shown a quarter-turn between two flights. The correct method of placing the risers in and around the curve, is to put the last one in the first flight one-half a step from springing *c*, and the first one in the second flight one-half a step from *a*, leaving a space in the curve equal to a full tread. By this arrangement, as shown in Fig. 132, the pitch-line of the tangents will equal the pitch of the connecting flight, thus securing the second easiest condition of tangents for the face-mould—namely, as shown, two equal tangents. For this wreath, only one bevel will be needed, and it is made up of the radius of the plan central line of the rail *o c*, Fig. 131, for base, and the line 1–2, Fig. 132, for altitude, as shown in Fig. 133.

The bevel shown in this figure has been previously explained in Figs. 105 and 106. It is to be applied to both ends of the wreath.

The example shown in Fig. 134 is of a well-hole having a riser in the center. If the radius of the plan central line of rail is made equal to one-half a tread, the pitch of tangents will be the same as of the flights adjoining, thus securing two equal tangents for the two sections of wreath. In this figure the tangents of the face-mould are developed, and also the central line of the rail, as shown over and above each quadrant and upon the pitch-line of tangents.

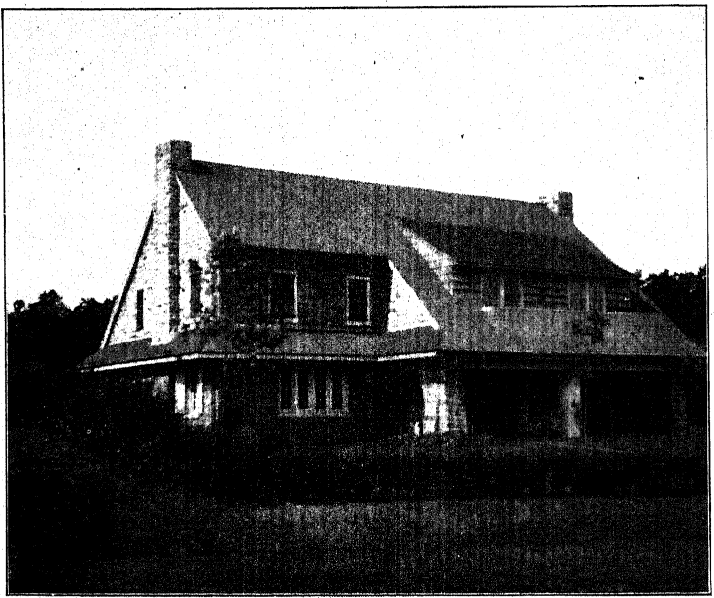
The same method may be employed in stairways having obtuse-angle and acute-angle plans, as shown in Fig. 135, in which two flights are placed at an obtuse angle to each other. If the risers shown at *a* and *a* are placed one-half a tread from *c*, this will produce in the elevation a pitch-line over the tangents equal to that over the flights adjoining, as shown in Fig. 136, in which also is shown the face-mould for the wreath that will span over the curve from one flight to another.

In Fig. 137 is shown a flight having the same curve at a landing. The same arrangement is adhered to respecting the placing of the risers, as shown at *a* and *a*. In Fig. 138 is shown how to develop the face-moulds.



HOUSE IN THE WHITE MOUNTAINS, NEW HAMPSHIRE

The Boulders, which are Plentiful in this Region, have been Used to Good Advantage.



HOUSE NEAR PHILADELPHIA, PA.

It is Verily a Part of the Landscape.

ESTIMATING*

PART I

Introductory. The ability to estimate may be considered as the dividing line between the journeyman and the master builder, for, no matter how skilful a mechanic may become, he can never "hang out his shingle" and invite patronage in his distinctive line of work, unless he becomes able to make reliable estimates of material and labor to be furnished. To do this something more than mere accuracy and quickness in figures or a mastery of mathematics is needed; namely: experience and judgment, an understanding of the more or less complicated details which go to make up a building, and a knowledge of current prices and discounts in the trade. It is the object of this paper to point the way toward the acquirement of such of these needs as may be imparted by words or figures; that is, to put in condensed form some of the common methods by which estimates are made up, and to point out some of the things which are to be avoided.

Prices. As prices of labor and materials are constantly shifting, those quoted in this paper must be taken only as proportionate, to be used in comparison with known quantities and methods. All prices given are as current in Boston, Mass., in December, 1906, and are subject to immediate change. On account of the variableness in price of labor and materials, it is better, in general, to make estimates on the basis of days or hours, and quantities of materials, so that they may be used for comparison in future work. To this end all estimates should be carefully labelled and filed away for future reference. This should be done whether the bids were successful or otherwise. If a successful bid, there will arise a good opportunity to compare the estimates of cost of the different items, with the actual cost of execution; and if a bid fails to win the job, satisfaction and experience may be gained by noting the items which may have been priced too high or too low. This data may be of great service in preparing future estimates, especially in the comparisons between estimated and actually executed work.

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*There is no such a thing as a universal or permanent standard price for anything. Prices vary in different localities at the same time, and in the same locality at different times. The estimator must therefore acquaint himself with local market conditions in every case.

Catalogues. Catalogues and price lists of all standard articles are easily obtained and should be kept at hand, properly indexed, for ready reference, as they contain a great deal of specific information. For close figuring, however, it will not do to rely upon these prices, as the amounts of trade discounts are not always included. These vary greatly from time to time, and often there are two or more discounts, a trade discount, a cash discount, and a variation in discounts made by different merchants, all of which the contractor must become aware of to obtain bottom prices.

All data of this sort should be carefully tabulated for constant reference, in such a form that it may be easily revised and kept, so far as possible, up to date.

The manner and time of payments is a matter to be considered in this connection, as it will permit the contractor to take advantage of cash discounts, which often make a great difference in the cost of certain materials.

Profit. To the actual price of labor and materials must be added the profit and this will need careful consideration. A common method is to add a lump sum to the estimated cost of labor and materials, varying with locality and customer, with the probable sharpness of competition and the circumstances of the contractor. This is a careless method, as it leaves no means for future comparison and no certain knowledge of just what the profits of a given job are.

Percentage. A better way is to base the profits upon a percentage of the estimated cost. This will vary, in ordinary cases, from ten to fifteen per cent, ten per cent being the least that should be expected on any work, and this is not enough for small contracts of two or three thousand dollars; but for large work, where there is a great duplication of parts and processes, it will be enough in most cases. Some contractors, whose workmen are required to perform especially skilful labor, figure fifteen per cent on all labor and ten per cent on materials.

Duplicate Parts. The matter of duplication is an important factor in estimating, as a considerable saving is often made if large quantities of material, either worked or unworked, are required; this is especially true in manufactured parts, such as doors and windows, columns, balustrades, etc. Modern machines are capable of duplication with astonishing rapidity, and workmen can put together similar parts more quickly and cheaply than variable members.

Transportation. The distance of the work from the shop of the contractor, or from centers of manufacture, will affect the cost to a marked degree, as much time is consumed in teaming and especially in handling material a number of times.

If communication between the works and the building site can be established by water, it will usually save considerable expense for freight and handling, with perhaps less risk of damage, and consequently less expense for crating and boxing. A careful study should be made of the means of transportation to each different building site from the shop, the office, and the mill, and the data kept for future reference, subject to varying rates and conditions, to change of seasons, and amounts to be transported.

These are some of the more important matters which require preliminary consideration as affecting all estimates, and are only a small part of the real questions involved, as different localities and customs require different treatment, and numerous questions will arise to confront the contractor, all of which may be successfully met, as we have seen, by the exercise of care and judgment.

Methods. Estimates are formed by many and varying methods, depending upon the degree of accuracy required, the capability of the contractor, and the character of the building. A broad division may be made between approximate estimates and accurate detailed estimates, only the latter of which should be considered when it is the intention to actually carry out the work under a definite contract.

Approximate Estimates. Approximate estimates are obtained with varying degrees of accuracy by several methods, the most convenient and reliable of which is the system of *cubing*; i.e., the cubical contents of the proposed building is obtained and multiplied by a given price per cubic foot. This rate is obtained by careful comparison of the plans and requirements with similar buildings which have been erected under conditions as like as possible to the conditions under which the proposed building can be erected.

Several methods are used to determine the cubical units, depending upon the size and shape of the proposed building. One method is to multiply the square feet in the plan of the building by the height from half-way the depth of foundations to half-way up the roof. Another system uses the height from the bottom of the foundation, and another obtains the actual cubical contents. Any of these may be used if the data for comparison is obtained in the same way, but all are subject to important variations which experience and judgment alone will determine. For instance, if the contour of the building is very uneven, with low portions, such as porches and sheds, and high portions, such as towers and cupolas, these must either be omitted from the whole and compared separately, or a lump sum be added or subtracted according to the size and elaboration of these members.

Another variation arises in the size of rooms, giving a ratio of partitions and division walls which is not constant, and of course a large building with many duplicate parts will require a different rating from a smaller one, so that the method of estimating by cubing is at best approximate, and its degree of accuracy depends largely upon the experience and judgment of the contractor. Even long experience will afford no safe-guard against unusual elaboration of interior or exterior, so that cube rates can only be applied to buildings of ordinary character, and comparisons are only reliable between buildings of like description and uses, as the treatment of even the same materials will vary largely in buildings of varying uses.

The height of the building will not increase the cube rate proportionately, unless the internal voids are alike, although it is certain that the higher one builds from the ground, the more time and expense it requires to put the material in place, to say nothing of thicker walls and necessarily heavier construction.

Estimating by the Square. A convenient method of estimating is by the square of one hundred surface feet. This is especially applicable to office buildings, schools, mills, stables, and all buildings where the floors are few in number or similar in plan. For one story buildings the price per square is taken to include the roof, walls, floor, and foundations, but for buildings of two or more stories the price per square should be taken separately for each floor, the lower floor being priced to include the foundations and the top floor to include the roof.

This method of estimating by the square is not so accurate as by cubical contents, but the results are often more convenient and adaptable, because the tabulation of the square area of the various floors may be easily reduced to terms of accommodation for public buildings or shops. For instance, a given floor area in a school house means accommodation for a certain number of pupils; in a church, a certain number of sittings; in factories for the manufacture of staple goods, a certain number of machines and operatives.

This unit of accommodation is sometimes carried further, and, by the reverse process, made the basis of another method of estimating the approximate cost of such buildings as the above mentioned, i.e., schools, churches, factories, hospitals, etc. This is also a method by comparison, the known data being supplied by previous experience or calculation, and it is often valuable as a means of determining the approximate cost of buildings necessary to accommodate a given number of individuals or machines, even before any definite plans have been drawn. All of these methods are approximate, with varying degrees of accuracy, and should never be advanced as accurate, or used as the basis of a contract, unless the contractor has had a long and varied experience and feels absolutely certain of his judgment, or unless a proper margin is added for possible variations.

Estimating by Quantities. The only sure and correct method of estimating is by taking off the actual quantities in detail and carrying out the prices accurately with the cost of labor, the percentage for profit, and contingencies added.

For this, accurate and complete drawings and specifications are necessary to give the absolute quantity and quality of materials and labor. The various items are then taken off, similar portions grouped, the amount of labor estimated, and a complete and classified schedule prepared and priced at current rates; the cost of transportation, board of men, and any other contingencies noted, a percentage of profit added, and a sum total reached which should be correct if faithfully done.

This, of course, takes considerable time, but is well worth the expense and trouble if a definite contract is to be made.

Preparation. In order to estimate to a sufficient degree of accuracy, some things other than the possession of plans and specifications are necessary. A visit to the site should be made, to ascertain the nature of the soil, the levels of the lot, the distance from railroad or wharf, the condition of the roads, if a long haul is necessary, and the preparation of the site necessary to receive and dispose of materials. Some knowledge should be obtained of the nature of the sub-soil, the presence of ledges or water below the surface which will require especial or costly treatment, etc. Often a deposit of sand will be found upon the site which will not only save carting away of material excavated, but, if of proper quality, it may be used for the work. Such items are constantly occurring so that a knowledge of existing conditions will be of great advantage to the estimator.

Regarding underground conditions, there is always an element of chance, as the most thorough examination will not always reveal hidden perils; the author knows of a case where a mason had contracted for the building of a sewer, and was in a fair way to make a good profit, when a narrow vein of quicksand was uncovered, to overcome which not only took away all the anticipated profit but caused a severe loss to the contractor besides.

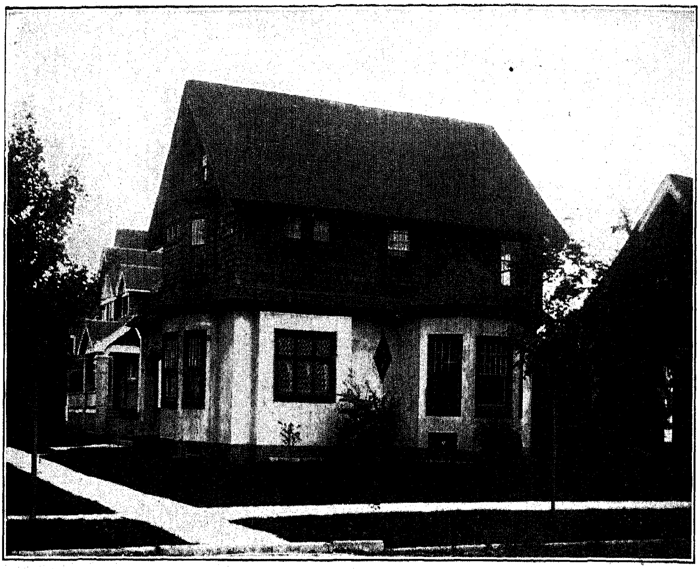
Ground water is another source of danger and it will be well for the contractor to closely examine his contract, to see to what extent he is to furnish protection from this source, as a vein of water which may have been temporarily stopped or diverted by the operation of building, will sometimes unexpectedly make its presence known during or after the completion of the work, when it may become a source of great annoyance and expense to the contractor if he has agreed to insure a waterproof job. Numerous illustrations could be given of the danger from unforeseen causes which can at best be only partially obviated by the most careful examination.

In order to accurately take off a building either by quantities, square or cube, a good knowledge of arithmetic is necessary; and, while we may assume that the reader already possesses this knowledge, it may be well to include some of the essential rules of that branch of arithmetic which is known as mensuration.

This consists primarily in the science of obtaining definite data regarding given figures or surfaces, such as areas, solids, capacity, linear dimensions, and comparisons of bodies.

Definitions. The *area,* or superficial dimension of any figure is the measure of its surface, without regard to its thickness or any other dimension.

The *cubical contents* of any figure is the measure of its solidity, or whole capacity, and has reference to the three dimensions, length, breadth, and thickness.



RESIDENCE FOR MRS. THOS. G. GAGE, ROGERS PARK, CHICAGO, ILL.

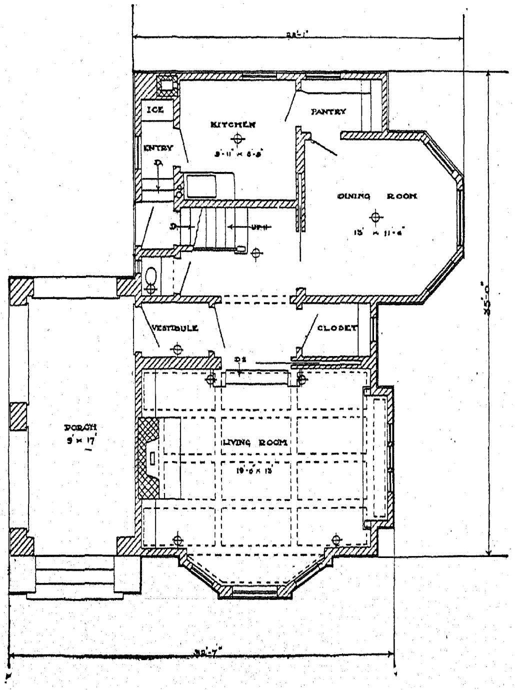
John B. Fischer, Architect, Chicago, Ill.

View Looking Southeast. Lower Story Cement, Rough Sand Finish; Second Story Finish Shingles Stained a Warm Brown; Woodwork around Windows and Gable Stained a Few Shades Darker than Shingles; Roof Shingles Stained a Dull Red.
For Interiors, See Page 251.

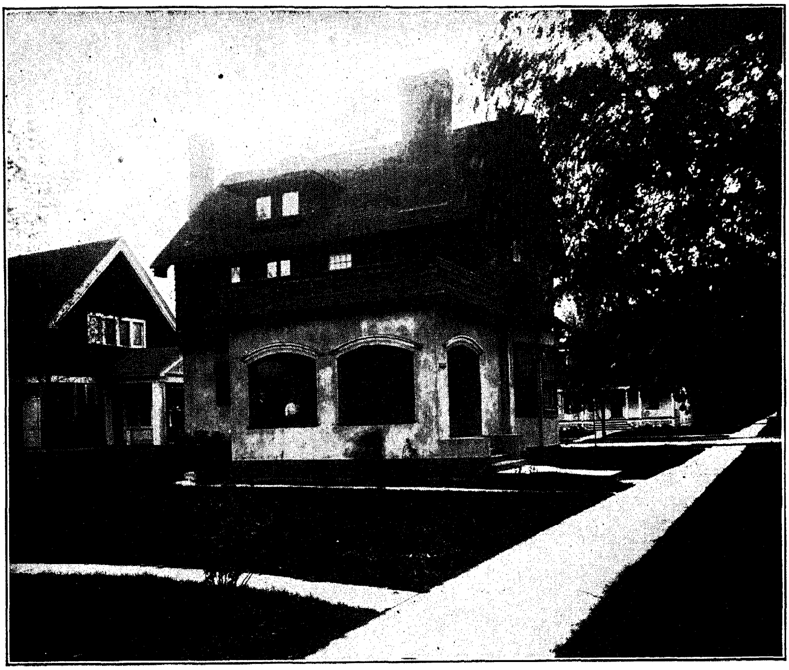
COST OF HOUSE:

Excavation	$ 27.50
Masonry	477.20
Carpentry	2,375.10
Sheet-Metal Work	70.00
Plastering	430.00
Plumbing and Gas fitting	450.00
Heating (Hot-Water)	449.40
Tile Work (3 Mantels, and Bath-room Floor)	193.60
Painting and Glazing	212.00
Hardware	60.00
Decorating	70.00
Electric Wiring	80.00
Electric and Gas Fixtures	83.20
Window Screens	20.00
Storm Sash	50.00
Window Shades	19.00
Cement Walk	23.00
Grading, Trees and Shrubs	72.00
Total	$5,162.00

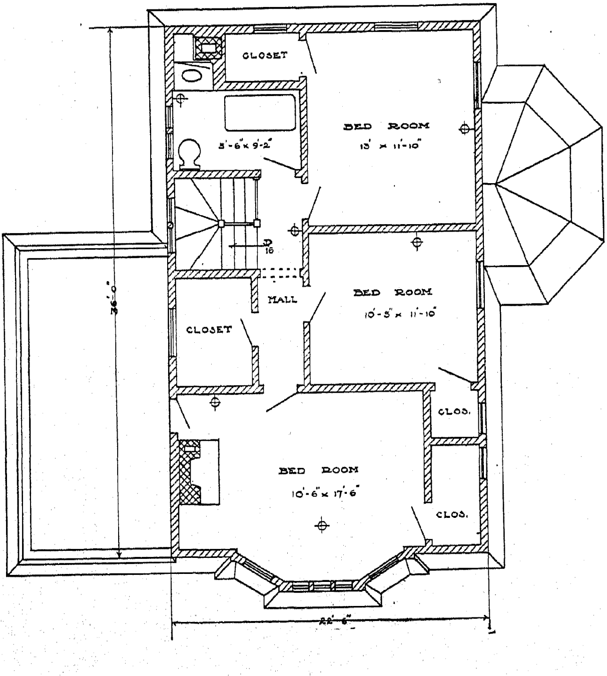
Built in 1903.



FIRST FLOOR PLAN
SCALE
FEET



RESIDENCE FOR MRS. THOS. G. GAGE, ROGERS PARK, CHICAGO, ILL.
John B. Fischer, Architect, Chicago
The Porch Faces East toward Lake Michigan.



SECOND FLOOR PLAN
SCALE
0 1 2 3 4 5 6 7 8 9 10 FEET

If the figure is considered as hollow, then the cubical contents becomes its *capacity* or capability of containing matter.

The *linear dimension* of a figure is expressed by its length in a direct line in any direction and has no regard to breadth or thickness.

Units. The application of these dimensions is made by fixing a unit by which the figure may be compared and the required dimension obtained; thus, for calculating the area of a figure the unit is usually a square, one side of which is the unit of length, and the area becomes the square measure of the figure.

This is expressed in common terms by square inch, square foot, square yard, or any other given unit and the measure of the surface is computed by obtaining the number of these square units which are contained in the figure, the process being called squaring.

In a similar manner the cubical contents or solidity of a figure is obtained by computing the number of cubical units which it contains, which is called cubing it.

Rules. Numerous rules have been adopted for obtaining these dimensions when given dimensions are known, and a tabulation of some of the more important and useful of these follows, by means of which it is hoped that the student may be able to solve most of the ordinary problems which will arise in common practice.

RULES AND TABLES

TABLE OF MULTIPLES

Circumference of a circle = diameter × 3.1416
Area of a circle = square of the radius × 3.1416
Area of a circle = square of the diameter × 0.7854
Area of a circle = square of the circumference × 0.07958
Area of a circle = half the circumference × half the diameter
Radius of a circle = circumference × 0.159155
Radius of a circle = square root of the area × 0.56419
Diameter of a circle = circumference × 0.31831
Diameter of a circle = square root of area × 1.12838
Side of an inscribed square = diameter × 0.7071
Side of an inscribed square = circumference × 0.2251
Side of an equal square = diameter × 0.8862
Area of a triangle = base by $\frac{1}{2}$ the altitude

Area of an ellipse = product of both diameters × .7854
Surface of a sphere = circumference × diameter
Surface of a sphere = square of the diameter × 3.1416
Surface of a sphere = square of the circumference × 0.3183
Solid contents of a sphere = surface × $\frac{1}{6}$ of its diameter
Solid contents of a sphere = cube of diameter × 0.5236
Diameter of a sphere = square root of surface × 0.56419
Diameter of a sphere = cube root of solidity × 1.2407
Circumference of a sphere = cube root of solidity × 3.8978
Solid contents of a cone or pyramid = area of base × $\frac{1}{3}$ altitude
Surface of a cube = six × area of one side
Area of trapezoid = altitude × $\frac{1}{2}$ sum of parallel sides

NOTE—Volumes of similar solids are to each other as the cubes of their similar lines.

MEASURE OF LINES AND SURFACE

1. To find the area of a parallelogram: *Rule*—Multiply the length by the breadth or perpendicular height. See Fig. 1

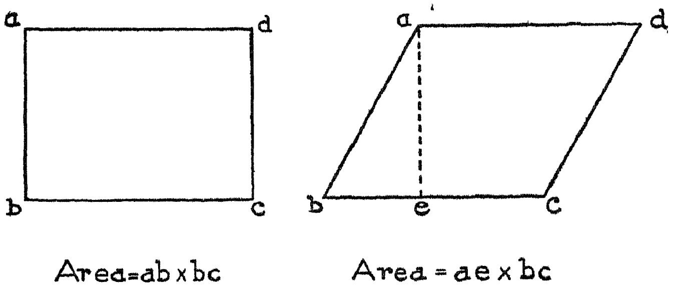
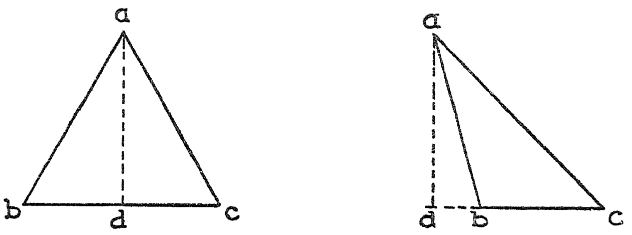


Fig. 1.

2. To find the area of a triangle: *Rule*—Multiply the base by half the altitude. See Fig. 2.

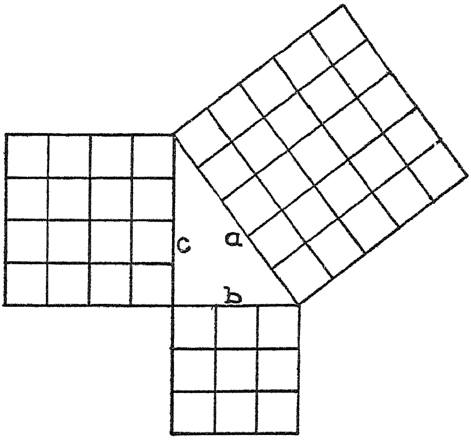
3. To find the hypothenuse of a right-angled triangle when the base and perpendicular are known: *Rule*—Add together the square of the known sides and extract the square root of the sum. See Fig. 3.

4. To find one side of a right-angled triangle when the hypothenuse and the other side are known: *Rule*—From the square of the hypothenuse subtract the square of the given side, and



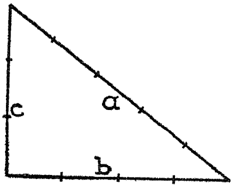
$$\text{Area} = bc \times \tfrac{1}{2}\,ad$$

Fig. 2.



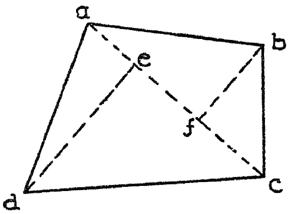
$$a = \sqrt{b^2 + c^2}$$

Fig. 3.



$$b = \sqrt{a^2 - c^2}$$
$$c = \sqrt{a^2 - b^2}$$

Fig. 4.



$$\text{Area} = \left(ac \times \tfrac{1}{2}\,bf\right) + \left(ac \times \tfrac{1}{2}\,de\right)$$

Fig. 5.

the square root of the remainder will be the other side. See Fig. 4.

5. To find the area of a trapezium: *Rule*—Divide the figure into triangles by drawing a diagonal and the sum of the areas of these triangles will be the area of the trapezium. See Fig. 5.

6. To find the area of a trapezoid: *Rule*—Add the two parallel sides and mutliply by one-half the perpendicular distance between them. See Fig. 6.

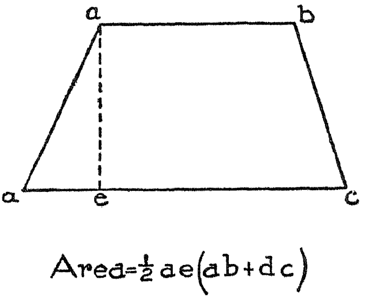


Fig. 6.

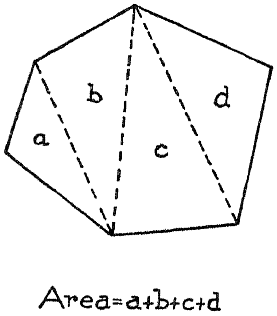


Fig. 7

7. To find the area of a regular polygon: *Rule*—Multiply one side by half its perpendicular distance from the center, and this product by the number of sides.

Table of Multiples to Compute Measurements of Regular Polygons, the Side of the Polygon Being Unity

NAME OF POLYGON	NO OF SIDES	A AREA	B RADIUS OF CIRCUMSCRIBING CIRCLE	C LENGTH OF THE SIDE.	D RADIUS OF INSCRIBED CIRCLE
Triangle..........	3	0.433013	0.5773	1.732	0 2887
Tetragon.......	4	1	0.7071	1.4142	0.5
Pentagon..	5	1.720177	0.8506	1.1756	0.6882
Hexagon.	6	2.598076	1	1	0.866
Heptagon	7	3.633912	1.1524	0.8677	1 0383
Octagon.......	8	4.828427	1 3066	0.7653	1.2071
Nonagon.....	9	6.181824	1 4619	0 681	1.3737
Decagon	10	7.694209	1.618	0.618	1.5383
Undecagon......	11	9.36564	1 7747	0 5634	1.7028
Dodecagon	12	11 196152	1.9319	0.5176	1.866

8. To find the area of a regular polygon when the length of a side only is given: *Rule*—Multiply the square of the side by the number opposite the name of the polygon in Column A.

9. To find the radius of a circumscribing circle when the

length of a side only is given: *Rule*—Multiply the length of a side of the polygon by the number in Column B.

10. To find the length of side of a polygon that is contained in a given circle, when the radius of the circle is known: *Rule*—Multiply the radius of the circle by the number opposite the name of the polygon in Column C.

11. To find the radius of a circle that can be inscribed in a given polygon, when the length of a side is given: *Rule*—Multiply the length of a side of the polygon by the number opposite the name of the polygon in Column D.

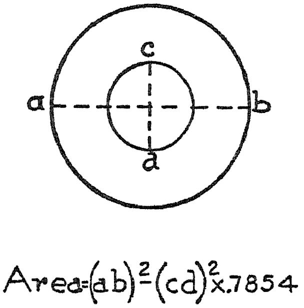


Fig. 8.

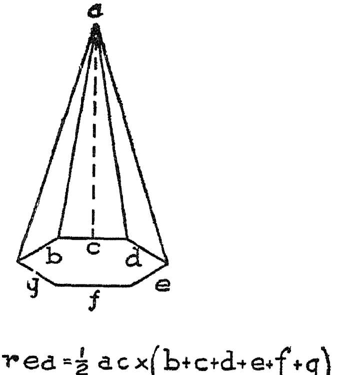


Fig. 9.

12. To find the area of an irregular polygon: *Rule*—Divide the polygon into triangles and add the areas of all the triangles. Fig. 7.

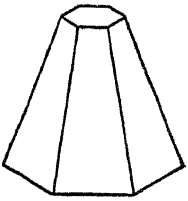


Fig. 10 Frustrum of Pyramid

13. To find the area of a ring included between the circumferences of two concentric circles: *Rule*—Square the diameters and multiply difference between the squares by .7854. Fig. 8.

14. To find the area of an ellipse: *Rule*—Multiply the two axes together and the product multiplied by .7854 will be the area.

15. To find the circumference of an ellipse: *Rule*—Square

AREAS OF CIRCLES

Size	Area	Size	Area	Size	Area	Size	Area
1/8	0.0123	10	78.54	30	706.86	65	3318.3
1/4	0.0491	1/2	86.59	31	754.76	66	3421.2
3/8	0.1104	11	95.03	32	804.24	67	3525.6
1/2	0.1963	1/2	103.86	33	855.30	68	3631.6
5/8	0.3067	12	113.09	34	907.92	69	3739.2
3/4	0.4417	1/2	122.71	35	962.11	70	3848.4
7/8	0.6013	13	132.73	36	1017.8	71	3959.2
1	0.7854	1/2	143.13	37	1075.2	72	4071.5
1/8	0.9940	14	153.93	38	1134.1	73	4185.3
1/4	1.227	1/2	165.13	39	1194.5	74	4300.8
3/8	1.484	15	176.71	40	1256.6	75	4417.8
1/2	1.767	1/2	188.69	41	1320.2	76	4536.4
5/8	2.073	16	201.06	42	1385.4	77	4656.0
3/4	2.405	1/2	213.82	43	1452.2	78	4778.3
7/8	2.761	17	226.98	44	1520.5	79	4901.6
2	3.141	1/2	240.52	45	1590.4	80	5026.5
1/4	3.976	18	254.46	46	1661.9	81	5153.0
1/2	4.908	1/2	268.80	47	1734.9	82	5281.0
3/4	5.939	19	283.52	48	1809.5	83	5410.6
3	7.068	1/2	298.64	49	1885.7	84	5541.7
1/4	8.295	20	311.16	50	1963.5	85	5674.5
1/2	9.621	1/2	330.06	51	2012.8	86	5808.8
3/4	11.044	21	346.36	52	2123.7	87	5944.6
4	12.566	1/2	363.05	53	2206.1	88	6082.1
1/2	15.904	22	380.13	54	2290.2	89	6221.1
5	19.635	1/2	397.60	55	2375.8	90	6361.7
1/2	23.758	23	415.47	56	2463.0	91	6503.8
6	28.274	1/2	433.73	57	2551.7	92	6647.6
1/2	33.183	24	452.39	58	2642.0	93	6792.9
7	38.484	1/2	471.43	59	2733.9	94	6939.7
1/2	44.178	25	490.87	60	2827.4	95	7088.2
8	50.265	26	530.93	61	2922.4	96	7238.2
1/2	56.745	27	572.55	62	3019.0	97	7389.8
9	63.617	28	615.75	63	3117.2	98	7512.9
1/2	70.882	29	660.52	64	3216.9	99	7697.7

To find the circumference of a circle when diameter is given, multiply the given diameter by 3.1416.

To find the diameter of a circle when circumference is given, multiply the given circumference by 31831.

the two axes and multiply the square root of half their sum by 3.1416.

AREAS OF SOLIDS

16. To find the lateral surface of a prism: *Rule*—Multiply the perimeter of the base by the altitude.

17. To find the lateral surface of a regular pyramid: *Rule*—Multiply the perimeter of the base by one-half the slant height. Fig. 9.

18. To find the lateral surface of the frustrum of a regular pyramid: *Rule*—Multiply the perimeters of the two ends by one-half the slant height. Fig. 10.

SOLID CONTENTS

19. To find the solid contents of a pyramid: *Rule*—Find the area of the base and multiply this by $\frac{1}{3}$ height.

20. To find the solid contents of a cylinder: *Rule*—Multiply the area of the base by the height.

21. To find the solid contents of a cone: *Rule*—Multiply the area of the base by $\frac{1}{3}$ of the height.

22. To find the solid contents of a sphere: *Rule*—Multiply the cube of the diameter by .5236.

SCALE OF WAGES

The item of cost of labor, on construction of any kind, is at best a variable quantity, dependent to a large degree upon competition, demand, and labor organization.

The cost of labor is steadily on the increase, while the hours of labor are continually decreasing. The tendency in both directions operates to a certain degree to lessen the effective power of labor, so that the amount of work done in a day is not what it represented a few years ago.

The various schedules given in the following pages are based upon the current price of labor in Boston, Mass., in 1906, and while this is likely to be upset somewhat by a general advance in 1907, there is not likely to be a great difference for some time. Blank spaces are left in these columns so that the student or contractor can fill in local or varying prices of labor.

Wages, Per Day of Eight Hours, in Various Trades, Boston, Mass., 1906

Carpenters	$3.28	....
Stone Masons	4.50	......
Brick Masons	4.80	......
Hod Carriers	2.40	.. .
Plasterers	5.00	.....
Plasterers' Helpers	3.00	.....
Lathers	4 50	. .
Quarrymen (9-hour day)	2 50	.....
Stone Cutters	4.00	.... ..
Tile Setters	4.80	....
Tile Helpers	2.60	... .

Roofers	$3 50 . . . .
Roofers' Helpers	2 25 . . . .
Steam Fitters	4.40 . . .
Steam Fitters' Helpers	2.25 . . .
Plumbers	4 40 . .
Plumbers' Helpers	1.50 . .
Gas Fitters	4 40 . . .
Gas Fitters' Helpers	2 25 . . .
Electricians	3.60 . . .
Painters	3.00. . . . .

EXCAVATION

Many considerations, seen and unforeseen, enter into the cost of excavations, of which the unforeseen conditions can, at best, be only judged of, making it more important that known circumstances should be carefully considered. Among these may be mentioned the varying kinds of soil and rock, the depth to which the excavation can be carried without shoring, the distance to which the excavated material is to be carried, and whether pumping or bailing will be necessary. Material excavated to a depth of six feet can be thrown on to the surface, but below this depth a stage will be necessary, or else it must be carted or wheeled out.

In taking off quantities for excavation, work in trenches should be kept separate from large areas, as the cost will be greater on account of lack of room for working.

Where the nature of the soil is uncertain, borings should be made or test pits dug, not only to reveal the character of the material, but to determine the depth at which "hard pan" is to be found. This is especially necessary when the specifications call for the foundations of any structure to be carried to hard pan, without reference to the drawings, or when no definite depth of footing is shown.

In the absence of full instructions, it is best to figure to excavate a foot outside of all walls or footings, to give ample working room; and trenches for pipes, etc., should be enough wider than the pipe to allow of working all around. Hollows should be made where hubs rest, so as to give a full bearing for the pipe.

In taking quantities in irregular ground, the plot should be divided into a number of definite squares and the contents of each square taken separately. See Fig. 11.

Cost of Excavating. The cost of excavating varies in different localities and under differing conditions, no two cases agreeing in details or in execution. The governing factors are experience and judgment. Excavating is usually priced by the cubic yard and will average about as follows:

Picking—12 cu. yds. per day at $2.40	$0 20
Throwing out—12 cu. yds. per day at $2.40	20
Wheeling 50 ft. away	10
	$0 50

Excavations in clay or very hard soil may cost from $0.50 to $1.00 while rock excavations will cost from $2.00 to $10.00, or more, according to the nature and position of the rock. Re-filling and packing around walls will cost usually from $\frac{1}{4}$ to $\frac{1}{2}$ of the price of earth excavations. Excavation of sand or loose gravel, which can be done by means of a horse scraper, will cost $0.30 per cu. yd.

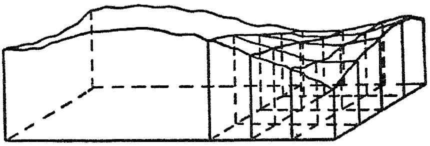


Fig. 11 Division of plot

Pile Foundations. The cost of piling varies with the nature of the soil and the length of pile necessary. Taking a 30-ft. pile as an average length, then piles 30 ft. long, driven and cut off level to receive footings, will cost $3.50 to $4.00 per pile.

STONE WORK

Stone walls are figured either by the perch or the cubic yard.

In taking off a stone foundation, it is customary to take the corners twice, that is, each different face of the wall is measured from out to out, thus doubling the corners. This makes up for the extra labor of laying up the corners.

The cost of a perch of rubble foundations laid in Rosendale cement mortar, 1 to 3, may be taken as follows:

1 perch of stone		$1 25
½ barrel cement	at $1 20	.60
⅙ load sand	at 1 75	.29
⅓ day, mason	at 4.50	1.50
¼ day, laborer	at 2.40	.60
Total cost per perch		$4 24

A perch of rubble wall laid in Portland cement mortar, 1 to 3, will cost:

1 perch of stone		$1 25
½ barrel Portland cement	at $2 10	1.05
⅙ load sand	at $1 75	.29
⅓ day, mason	at 4 50	1 50
⅓ day, laborer	at 2.40	.80
Total cost per perch		$4.89

Cut Stone. Cut stonework is figured by the cubic foot, the prices differing according to the amount of labor involved in the cutting; and this will depend somewhat upon the nature of the stone, a hard stone being more expensive to prepare than a soft one. The principal kinds of stone used in building are granite, limestone, sandstone, marble, and bluestone.

Granite. Granite is one of the hardest stones to quarry and prepare, and, on account of its cost it is not so freely used as limestone or marble. Granite in rough blocks from the quarry will cost 45 to 60 cents a cubic foot, the cutting of beds and joints will cost 25 cents for each square foot of surface so treated. If the face is pitched off to a line with rock face, it will cost 25 cents per square foot, while hammering in 8-cut work will cost 70 cents per square foot. Quincy granite will cost, in the rough, about double this, or $1.20 per cubic foot; the cutting will cost one-third more.

From this data we may deduce the following scale:

Granite, in rough blocks at quarry,	per cu. ft.	$0.60
Add for beds and joints	per sq. ft.	.25
Add for rock face, pitched off to a line,	per sq. ft.	.25
Add for 8-cut work	per sq. ft.	.70

Hence the facing of an average wall with 8 inches of granite will cost, if the stones are about 2 feet x 3 feet, or 6 surface feet in each block:

Stock, 4 cu. ft.	at .60	$2.40
Beds and end joints $2\frac{2}{3}$ sq. ft.	at .25	.67
Rock face 6 sq. ft.	at .25	1 50
Cost of 6 superficial ft.		$4 57

or $76\frac{1}{6}$ cents per square foot.

If the same were finished in 8-cut work, the cost of finishing the surface would be 70 cents a square foot instead of 25 cents, making the cost per square foot 45 cents more, or about $1.21 a square foot.

Limestone. Limestone is used to a large extent, especially in conjunction with brick, for trimmings for various kinds of buildings. Limestone will cost at the quarry about 30 cents a cubic foot; this will apply to Indiana limestone only. Lake Superior redstone will cost 35 cents; Ohio sandstone, 50 cents. In estimating, about 20 per cent should be added for waste, 5 per cent quarry waste, and 15 per cent for cutting waste:

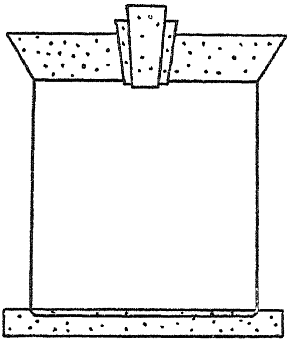


Fig 12. Limestone Window Set

*** Prices of Common Shapes of Limestone**

Water table, 8 in. x 12 in.	per lineal foot	$1 50
Steps, 7 in. x 14 in without nosing.	per lineal foot	1 50
Steps, 7 in x 14 in with nosing	per lineal foot	2 50
Door sills, 8 in. x 12 in	per lineal foot	1 25
Window sills, 5 in. x 12 in	per lineal foot	1 00
Window sills, 5 in x 8 in.	per lineal foot	75
Window caps, 4 in. x 10 in.	per lineal foot	.70
Window caps, 8 in. x 12 in.	per lineal foot	1 00
Wall coping, 5 in. x 20 in.	per lineal foot	1 50
Platforms and large slabs, 6 in. thick,	per sq. ft.	2 00

***Window Sets.** A common use of limestone is in the form of window sets, consisting of a flat arch in three pieces with keystone, and a light sill, as shown in Fig. 12.

---

*These prices are based on a freight charge of $0 55 per cu ft to Boston
The freight on Lake Superior stone is 55
The freight on Ohio stone .41

The rise of these caps is about 10 inches, and the rise of the sill 5 inches. These sets for an average sized window, say 4-foot opening, will cost for a 4-inch reveal $10, and for an eight-inch reveal $15.

Sandstone. The cost of dressed sandstone is about 10 per cent more than that of limestone.

Setting. The cost of setting cut stone may be taken at 15 cents a running foot for window trimmings and ashlar work, and 20 cents for platforms, water table, steps, etc. Trimming and fitting at the building will cost about 10 cents per cubic foot.

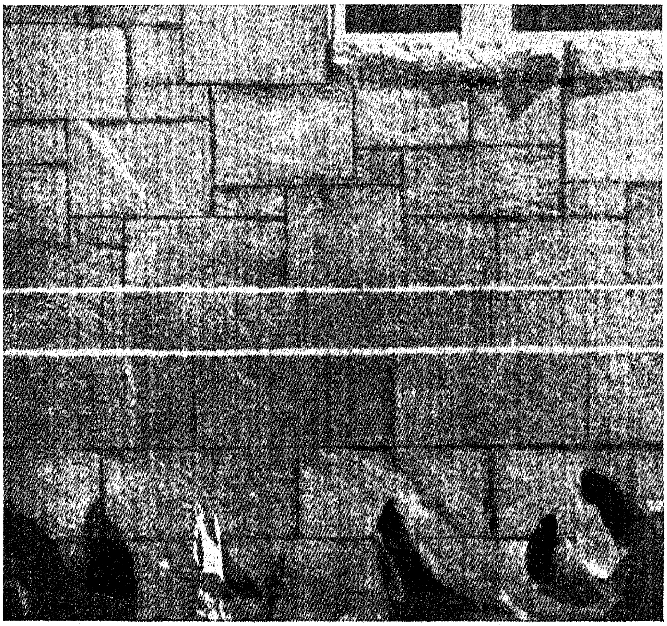


Fig. 13. Seam-Faced Granite Wall.

The foregoing prices are based upon quarry-men's wages at $2.50 per day, and stone cutters' wages at $4.00 per day.

Much of the cutting and finishing of stone is done by machinery, so that the question of wages will not enter into the preparation of the stock so largely as in many other branches.

Marble. A more expensive stone to use is marble, which can be obtained in a variety of colors, in different parts of the country. The price of marble differs in different localities but for general purposes may be taken as about double the figures which we have quoted for limestone.

Bluestone. Bluestone is used in the East mainly for flagging, copings, etc., but is used to a considerable extent for building, in Central and Western sections. The price of bluestone flagging 3 inches thick with trimmed joints and face planed and dressed, will be 65 cents a square foot; with natural face, 35 cents to 45 cents. Bluestone ashlar 8 inches thick with natural face and dressed joints, will cost $1.00 per square foot, and 15 cents a square foot for setting.

Seam-Faced Granite. In some localities granite, lying in upturned strata with open weathered seams, is to be obtained. This is used for facing walls in ashlar work, being set on edge in the wall with the seam-face showing; this will cost, in place, 4-inch to 8-inch thick, from 60 cents to 75 cents a superficial foot. See Fig. 13.

BRICKWORK

Brickwork is usually estimated by the thousand bricks, but is sometimes priced by the cubic foot at 40 cubic feet to a thousand. A mason in one day will lay from 800 to 1,000 common bricks, or 300 to 400 face bricks.

The number of bricks in a wall may be found by multiplying the superficial area by 7½ for each 4 inches of the thickness of the wall. Openings of the size of ordinary windows are generally deducted, but very small openings will cost more to make than the deduction. An allowance for breakage should be made of 5 per cent.

Mortar. Bricks are laid in mortar made of *lime* or *cement*, according to the strength required. Lime mortar should not be used in damp situations, or where great strength is required. The difference in cost of lime and cement mortar is so little that cement mortar is generally used.

The building laws of some cities require brick work to be laid in cement mortar for a certain part of the height.

Cement mortar makes a darker joint, but where a white joint is required it can be obtained, without loss of strength, by using Portland cement and lime mortar.

Cost. The cost of brickwork by the thousand in various kinds of mortar may be analyzed as follows:

In 1 – 3 lime mortar,

1,000 bricks	$ 9.00
3 bu. lime at $.36 per bu.	1 08
½ load of sand at $1.75 per load	.88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3 00
	$19.96

In 1 – 3 Rosendale cement mortar:

1,000 bricks	$9.00
1½ bbl. Rosendale cement at $1.20	1.80
½ load sand	88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3.00
	$20.68

In 1 – 3 Portland cement mortar:

1,000 bricks	$ 9 00
1¼ bbl. Portland cement at $2.10	2.62
½ load sand at $1.75	.88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3 00
	$21.50

From these tables we may deduce an approximate estimate in round numbers as follows:

1,000 bricks laid in 1 – 3 lime mortar	$20.00
1,000 bricks laid in 1 – 3 cement mortar	21.00
1,000 bricks laid in 1 – 3 Portland cement mortar	22.00

So that, on a job of ordinary size, the difference between lime and cement mortar ought not to be considered, where cement mortar will give assurance of greater stability.

Face Bricks. Face bricks in great variety, are to be had either plain or moulded, and in a variety of colors. On ordinary face brickwork a mason with tender will lay about 300 to 400 bricks in a day.

Faced bricks cost from $25.00 to $50.00 per thousand; a good average brick can be secured for $32.00 This will make the price for a thousand, laid, about as follows:

1,000 face bricks	$32.00
1¼ bu. lime at $.36	.45
½ load fine sand at $1.75	.88
3 days, mason at $4.80	14.40
1½ days, tender at $2.40	3.60
	$51.33

From this we find that 1,000 face bricks can be laid in the wall for $51.33 of which $33.33 goes for stock and $18.00 for labor.

Enameled bricks are to be had in various colors, white and buff being the most common. These bricks cost from $50.00 to $60.00 per M.

Concrete. Concrete is used to a great extent now for footings, walls, piers, etc. The cost of concrete is not a great deal different from stone for foundations and if there is uncovered a deposit of suitable sand and gravel, as is sometimes the case, it can be put in at a less price than a granite footing.

Concrete with a reinforcement of steel is used in various forms for piers, floors, and walls.

The cost of a cubic yard of concrete, using the proportion of 1 - 3 and 6, may be summarized as follows:

1 bbl. Portland cement	$2.10
3 bbl. sand	.75
6 bbl. broken stone	2.00
Mason, 2 hours at $.60 per hour	1.20
Laborer, 4 hours at $.30 per hour	1 20
	$7.25

Cellar concrete 3 inches thick will cost $.60 to $.75 per square yard in place. Concrete of Rosendale cement can be put in at less cost, being for foundation walls about $6.00 per cubic yard; for piers $6.50 per cubic yard.

MISCELLANEOUS DATA

CHIMNEYS

Chimneys may be quickly estimated by the lineal foot of height, as follows:

1 flue 8 in. x 8 in. per foot	$0.90	with flue lining	$1 10
1 " 8 in. x 12 in. per foot	1 00	" " "	1.25
1 " 12 in. x 12 in. per foot	1.20	" " "	1.50
2 flues 8 in. x 8 in. per foot	1.40	" " "	1 80
2 " 8 in. x 12 in. per foot	1.75	" " "	2.20

FLUE LINING

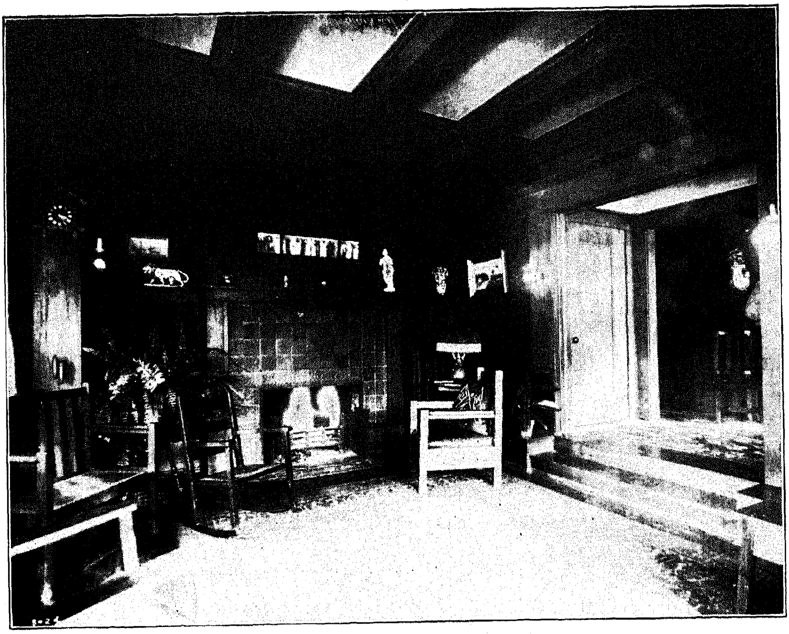
Net price per foot, outside dimensions.

4½ in. x 8½	inches	$.10	8½ in. x 17½	inches	$ 32
4½ in. x 13	"	.16	13 in. x 13	"	.30
8½ in. x 8½	"	.16	13 in. x 18	"	.42
8½ in. x 13	"	.22	18 in. x 18	"	.70

For openings add one-third.

MASONS' SUPPLIES

Portland Cement	$ 2 10	per bbl.
Rosendale Cement	1 20	" "
Extra Lime for Skimming	1.15	" "
No. 1 Lime for Mortar	1.05	" "
Vermont Lime	1.20	" "
Plaster, 250 lb. bbls.	1.60	" "
Mortar Color, Red, in bbls.	.01¼	per lb.
Mortar Color, Red, in 100 or 200 lb. keg	.01½	" "
Mortar Color, black	.03½	" "
Philadelphia Pressed Brick, for fireplaces	35.00	per M.
Fire Brick	35 00	" "
Best Plastering Hair	.25	per bush.
Mortar Hods	1.50	each
Brick Hods	1.25	"
10-in. Mortar Hoes	.50	"
Good No. 2 Shovels, square point, plain back	.75	"
Sand Screens, wood leg	6.00	"
Bolted Dump Barrows	2.00	"



East End of Living Room

The Mantel is Faced with Green Unglazed Tile. Flat-Sawed Oak Finish, Stained Brown and Waxed; Plaster Work, Rough Sand Finish Painted.

West End of Living Room

RESIDENCE FOR MRS. THOS. G. GAGE, ROGERS PARK, CHICAGO, ILL.

John B. Fischer, Architect, Chicago

For Plans and Exteriors, See Page 234.

Metal Corner Bead		$0.04 per ft.
Iron Rim and Cover, 20 in. diameter		3.50 each
" " " 18 in. "		3.00 "
" " " 15 in. "		2.50 "

CELLAR COLUMNS

For cellar supports, in place of brick piers, pipe columns consisting of a steam pipe filled with cement, under a patent, are coming into general use in many localities.

These columns cost less, and take up less room than a brick pier of equal strength. The prices are as follows:

Size.	7 Ft.	8 Ft	9 Ft.	10 Ft
3 in.	$1.65	$1 90	$2 20	$2.65
3½ in.	1.90	2.20	2 65	3.15
4 in.	2 75	3 25	3 80	4.40
4½ in.	4 00	5 00	5 50	6.00
5 in.	5.00	5.85	6 65	7.55
6 in.	6.00	6.95	8.00	9.30

EARTHEN DRAIN PIPE

For sewer and cesspool connections and general drainage, earthen vitrified drain pipes are used. These are laid in cement and, if well below frost or danger of breaking, make a more durable pipe than cast iron, besides being much less costly.

Net Price of Standard Vitrified Pipe

Inside Diameter	Price per Foot	Bends and Curves	Weight per Foot
2 in.	$0.05	$0.17	6 lbs.
3 in.	.05	.17	8 "
4 in.	07	.23	10 "
5 in.	.08¾	.30	12 "
6 in.	.10	.38	16 "
8 in.	.17	.70	24 "
10 in.	26	1.00	34 "
12 in.	.35	1.40	45 "
15 in.	.47	1.90	67 "
18 in.	.60	2.38	86 "

CARPENTRY

The Carpenter-Work of a building includes, in general, the skeleton or frame, if a wooden building, the floor timbers, studs of partitions and walls, rafters, the covering in of the frame, with its exterior finish and clapboards, siding or shingles, the flooring, furring, grounds, and beads. This practically covers the constructive woodwork or carpentry proper, while to the term joinery belongs the outside and inside finish, windows and doors, sheathing and dado, stairs and fixtures.

In many sections the general term carpentry covers all woodworking and covering, while in others the distinction between the carpenter and the joiner is more distinctly drawn.

For the purposes of this work it will not be necessary to hold this distinction, and so for convenience, the term carpentry will be used to cover all branches of woodworking.

Two distinct elements enter into the carpenter-work of any structure; the *Material* and the *Labor*, and the cost of both is subject to fluctuation to a great extent. The trend in both is in the direction of increased cost in varying degrees in different localities, but the state of the market in both labor and materials is never quiescent, so that any printed prices must be considered as comparative only, and must be carefully compared with local and known data before being accepted as accurate or final.

The material with which the carpenter works, consists in the main of three principal divisions, the *Frame*, the *Covering*, and the *Finish*, and each of these has further subdivisions as will be noted.

Board Measure. All lumber which has not been wrought or moulded, is sold by "board measure" that is, the stock in each piece is reduced to a unit of a square foot of board one inch thick. This is called board measure and is expressed by the abbreviation B. M. Prices of lumber are usually rated by the thousand feet, so that the expression "Twenty-five dollars a thousand" means twenty-five dollars for a thousand square feet of stock one inch thick. To reduce stock of greater thickness than one inch, to its equivalent in board measure, several rules may be used.

A convenient method is to divide the product of the width and thickness in inches by 12, and multiply by the length in feet.

TABLE OF BOARD MEASURE

Size in Inches	Length in Feet											
	10	12	14	16	18	20	22	24	26	28	30	32
2 x 3	5	6	7	8	9	10	11	12	13	14	15	16
2 x 4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16	17⅓	18⅔	20	21⅓
2 x 5	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20	21⅔	23⅓	25	26⅔
2 x 6	10	12	14	16	18	20	22	24	26	28	30	32
2 x 7	11⅔	14	16⅓	18⅔	21	23⅓	25⅔	28	30⅓	32⅔	35	37⅓
2 x 8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
2 x 9	15	18	21	24	27	30	33	36	39	42	45	48
2 x 10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	43⅓	46⅔	50	53⅓
2 x 12	20	24	28	32	36	40	44	48	52	56	60	64
2 x 14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56	60⅔	65⅓	70	74⅔
2 x 16	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
3 x 4	10	12	14	16	18	20	22	24	26	28	30	32
3 x 5	12½	15	17½	20	22½	25	27½	30	32½	35	37½	40
3 x 6	15	18	21	24	27	30	33	36	39	42	45	48
3 x 7	17½	21	24½	28	31½	35	38½	42	45½	49	52½	56
3 x 8	20	24	28	32	36	40	44	48	52	56	60	64
3 x 9	22½	27	31½	36	40½	45	49½	54	58½	63	67½	72
3 x 10	25	30	35	40	45	50	55	60	65	70	75	80
3 x 12	30	36	42	48	54	60	66	72	78	84	90	96
3 x 14	35	42	49	56	63	70	77	84	91	98	105	112
3 x 16	40	48	56	64	72	80	88	96	104	112	120	128
4 x 4	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
4 x 5	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	43⅓	46⅔	50	53⅓
4 x 6	20	24	28	32	36	40	44	48	52	56	60	64
4 x 7	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56	60⅔	65⅓	70	74⅔
4 x 8	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
4 x 9	30	36	42	48	54	60	66	72	78	84	90	96
4 x 10	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80	86⅔	93⅓	100	106⅔
4 x 12	40	48	56	64	72	80	88	96	104	112	120	128
4 x 14	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112	121⅓	130⅔	140	149⅓
6 x 6	30	36	42	48	54	60	66	72	78	84	90	96
6 x 8	40	48	56	64	72	80	88	96	104	112	120	128
6 x 10	50	60	70	80	90	100	110	120	130	140	150	160
6 x 12	60	72	84	96	108	120	132	144	156	168	180	196
6 x 14	70	84	98	112	126	140	154	168	182	196	210	224
6 x 16	80	96	112	128	144	160	176	192	208	224	240	256
8 x 8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128	138⅔	149⅓	160	170⅔
8 x 10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160	173⅓	186⅔	200	213⅓
8 x 12	80	96	112	128	144	160	176	192	208	224	240	256
8 x 14	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224	242⅔	261⅓	280	298⅔
10 x 10	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200	216⅔	233⅓	250	266⅔
10 x 12	100	120	140	160	180	200	220	240	260	280	300	320
10 x 14	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280	303⅓	326⅔	350	373⅓
10 x 16	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320	346⅔	373⅓	400	426⅔
12 x 12	120	144	168	192	216	240	264	288	312	336	360	384
12 x 14	140	168	196	224	252	280	308	336	364	392	420	448
12 x 16	160	192	224	256	288	320	352	384	416	448	480	512
14 x 14	163⅓	196	228⅔	26⅓1	294	326⅔	359⅓	392	424⅔	457⅓	490	522⅔
14 x 16	186⅔	224	261⅓	29⅔8	336	373⅓	410⅔	448	485⅓	522⅔	560	597⅓

Example. How many feet, B. M., are there in a joist 2 in. x 9 in., 20 ft. long?

$$\frac{2 \times 9}{12} \times 20 = 30 \text{ ft. B. M.}$$

When the sizes are fractional, or produce a product not easily divided by 12, the operation may sometimes be simplified by varying the process and multiplying the length in feet, and the thickness and width in inches together, and dividing the whole product by 12.

Example. How many feet are there in a joist $2\frac{1}{2}$ in. x 9 in., 16 ft. long?

$$\frac{16 \times 2\frac{1}{2} \times 9}{12} = 30 \text{ ft. B. M.}$$

MISCELLANEOUS PRICES OF LUMBER

LUMBER

Dimension spruce lumber up to 9 inches of depth will cost at present per M., board measure.	$26 00
10-inch stock, per M.	30.00
For long lengths, add per M.	2.00
Hemlock boarding	24.00
Spruce boarding	25.00
Spruce boarding matched	27.00
Spruce upper floor	45.00
Extra shingles	4.00
Clear shingles	3.50
Spruce clapboards	50 00
Siding cypress	30.00
Drop or novelty siding	55.00
Laths	5.00
Georgia pine timbers 12 in.	35 00
Georgia pine timbers 14 in.	40.00
Georgia pine timbers 16 in.	50.00

FLOORS AND FINISH

Georgia pine, heart face rift	$70 00
Georgia pine, common rift	45.00

Maple flooring	$ 55.00
Quartered oak flooring	125.00 to 150.00
North Carolina pine, rift stock	40 00
North Carolina pine, slash stock	33.00

FINISH

Georgia pine	$ 45 00
Cypress No. 1	80 00
Cypress No. 2	75.00
Oak, plain	90.00
Oak, quartered	120 00
Birch	65.00
Whitewood	52.00
Ash	55.00
Elm	40.00

INSIDE DOOR FRAMES

2 ft. 8 in. x 6 ft. 8 in.	$1.00
2 ft. 10 in. x 6 ft. 8 in.	1.10
3 ft. 0 in. x 7 ft. 0 in.	1.15
For transom bars add	.75

Calculating the Frame. In taking off the rough frame of a house or the purposes of estimating, the most accurate method is to take a chedule of every piece of timber from the framing plans, but as it often appens that the estimates are asked for from the general drawings, efore framings are made, it has become the custom in many ections to estimate the cost of the walls and floors by the square of 00 superficial feet, making separate allowance for sills, girders, lates, and other large timbers.

If it is desired to take off the frame separately in the absence f framing plans the following data may be of use.

The sills of an ordinary house will usually be from 6 in. x 6 in. o 6 in. x 10 in., girders from 6 in. x 8 in. to 8 in. x 10 in., and loor joists from 2 in. x 8 in. to 3 in. x 12 in. generally 16 in. on enters. Wall studding of outside frame and bearing partitions will sually be 2 in. x 4 in. – 16 in. on centers. Studding of closets and light walls will usually be 2 in. x 3 in., plates 4 in. x 4 in. and 4 in. x 6 in., sometimes two 2 in. x 4 in. doubled, rafters from 2 in. x 6 in. to 2 in. x 12 in. and 18 in. to 24 in. on centers.

In taking off the frame, the sills and plates will of course be measured by the linear feet in the outside wall. The position of the main bearing partitions will usually give the number and location of the girders. Studs are doubled at openings and at corners, and fireplaces and stair openings will call for timbers of a large size, say from 6 in. to 8 in. width.

Assuming that the joists are 16 in. on centers, the number of joists on a floor will be given by taking ¾ of the length of the building in feet, and adding one joist. The number of studs in the outside frame at 16 in. on centers may be found by taking ¾ of the number of lineal feet in the outside of the building, adding one stud for each corner, and one for each door and window. To this must be added any gables or bay windows or other projections. Three quarters of the number of lineal feet of partitions will give the number of studs in the inside frame at 16 in. on centers. This allows for doubling of studs at openings and corners.

For the number of rafters take the length of the building divided by the distance of the rafters apart and add 1, this gives the number of pairs of rafters if a plain gable roof, while the number of rafters in a hip roof can be found by dividing the whole distance around the building by the distance apart.

Cost of Frame. Spruce lumber is generally used for framing, but Georgia pine must sometimes be used for large girders.

The cost of spruce lumber is from $26.00 to $28.00 per M., for sizes 9 in. and under; $30.00 for 10 in. stock, with a corresponding increase for large sizes. Hard pine lumber, 12 in. and under, will cost $35.00 per M.; 14 in. sizes $40.00; 16 in. sizes $50.00, and so on. Hard pine from the South by shipload will cost about $5 00 less per M.

The labor of framing sills, girders, etc., will cost about $10.00 per M.; plates, rafters, etc. $12.00. From this we estimate that a section of sill 30 ft. long, containing 90 ft. B. M. will cost as follows:

Stock, 90 ft. B. M. of 6 in. x 6 in. spruce at $26.00 per M.	$2.34
Labor of framing at $10.00 per M.	.90
	$3.24

Dividing this by 30, the length in feet, we get 10$\frac{8}{10}$ cents, or about 11 cents a running foot. In this same way the posts, girts, and other special timbers may be figured.

Floors. Having disposed of the large timbers separately we can now take up the floors by the *square of* 100 *feet*. An analysis of this gives us a result as follows:

Cost of a Square of Flooring:

Joists 2 in. x 9 in., 16 in. on centers, 112½ ft. B. M. at $26.00	$2 92
Labor, per square of 100 sq. ft.	1 50
Nails	.10
Bridging	.50
Under floor, 100 ft. Hemlock at $24.00	2 40
Waste ⅓ of stock	.80
Labor	.75
Nails, 5 lbs. at 3 cents per lb.	.15
Strapping for ceiling 1 in. x 2 in., 16 in. on centers	.40
Nails	.10
Labor	1.00
Upper floor, 100 ft. of Spruce at $40.00	4.00
Waste	1.30
Labor	1.50
Nails	.15
Paper, labor, and stock	.25
Total per square	$17.82

In the same way we may estimate the cost of the walls as follows:

Outside Walls, boarded:

Studding 2 in. x 4 in., 16 in. on centers, 50 ft. B. M. at $26.00	$ 1.30
Waste ⅓ stock	.43
Nails	.25
Labor, per square, studding	1.50
Beads and grounds	.25
Boarding, 100 ft. hemlock at $24.00	2.40
Waste ¼ stock	.60
Labor per square, boarding	.75
Nails	.15
Total cost per square	$ 7.63

Shingling the outside walls will cost:

Shingles, 850 at $4.25	$3 61
Paper and laying	.50
Nails	.25
Labor on shingling per square	2 18
Total cost of shingling	$6 54

Roofing with 2 in. x 6 in. rafters spaced 20 in. on centers will cost:

2 in. x 6 in. rafters 20 in. on centers at $26.00	$1.56
Waste ¼	.39
Labor	2.00
Nails	.10
Boarding	2.40
Waste	.60
Labor	1.00
Nails	15
Total cost per square	$8.20

Inside studding ready for lathing will cost:

Studs, 2 in. x 4 in., 16 in. on centers, 50 ft. B. M. at $26.	$1.30
Waste ½ stock	.65
Nails	.15
Labor, per square	1.50
Beads and grounds	.40
Total cost per square	$4.00

Windows of average size in place will cost approximately:

Window frame	$1.20
Sashes 3 ft. x 5 ft.	1.75
Blinds	1.00
Blind fastenings	.15
Weight, 30 lbs. at 1¼ cents per lb.	.38
Sash cord, 20 ft. at 1 cent per ft.	.20
Sash fast	.25
Inside casings, 20 ft. at 3½ cents per ft.	.70
Stop beads, 16 ft. at 1¾ cents per ft.	.28
Labor, 8 hours at 41 cents per hour	3.28
Total cost of window in place	$9.19

Inside doors of average size will cost, complete:

Door 2 ft. 8 in. x 6 ft. 8 in. x 1½ in. pine, to paint	$2.40
Frame	1.00
Casings	1.33
Threshold	.15
Nails	.05
Hardware	1.25
Labor, 8 hours at 41 cents	3.28
Total cost of door in place	$9.46

Rift hard pine upper floors will cost, per square of 100 square feet:

Rift hard pine flooring, 100 ft. B. M. at $65.00	$ 6 50
Waste and matching ⅓ of stock	2 16
Labor	2.00
Nails, 5 lbs. at 3 cents per lb.	.15
Paper	.25
Total cost of floor per square	$11.06

Approximate cost per square ft.	11 cents
Finishing with shellac and wax	3 cents
Total per square foot finished	14 cents

Quartered oak floor, per square ft.	25 cents
Finishing with shellac	4 cents
Total cost per square foot	29 cents

A common front door will cost:

Door 3 ft. 4 in. x 7 ft. 0 in. x 1⅞ in.	$ 5.75
Frame	4.50
Plate glass	2.50
Casings, 20 ft. at 4 cents	.80
Hinges	.68
Lock and knobs	4.50
Labor	4 00
Total cost of door	$22 73

A pair of sliding doors, fitted complete, will average about as follows:

2 doors 3 ft. 0 in. x 7 ft. 0 in. x 1¾ in. each	$6 00
44 feet casings, at 4½ cents	1.98
40 feet grounds, at 1 cent	.40
40 feet stop beads, at 2 cents	.80
Astragal	1.00
Chafing strip	.20
Lock	4.50
Hangers and track	4.50
Sheathing pocket, 84 ft. at 40 cents	3 36
Labor, 40 hours at 41 cents	16.40
Total cost of doors	$39.14

These are some of the principal parts of a house analyzed and will serve to show how the cost of any portion may be obtained by dividing it into parts and pricing each portion by itself.

Following are some miscellaneous details of carpenter work: Two carpenters working in pairs can put up in a day about

300 ft. B. M. of studding.
300 ft. B. M. of rafters.
600 ft. B. M. of floor joist.
800 ft. B. M. of wall or roof boarding.
600 ft. B. M. of matched boarding.
500 ft. B. M. of diagonal matched boarding.

MISCELLANEOUS ITEMS

CELLAR WINDOW

Frame	$1 50
Sash	1.20
Hardware	.15
Labor	.50
	$3.35

CELLAR DOORS

Stock door, 2 ft. 8 in. x 6 ft. 8 in. x 1½ in.	$2 25
Frame	1.00
Finish, 36 ft. 4½ in. finish	1.62

Threshold	$0.15
Hardware	.85
Labor	3.00
	8.87

Paper on walls under clapboards or shingles per square:

Paper	$0.20
Laying	.05
	$0.25

Inside Finish. Inside finish in white wood or cypress, cost in place:

8 in. base board with 2 in. moulding, per running ft.	$0 12
4 ft. wainscot of narrow sheathing, per running ft.	40
Plain wall sheathing, per square foot	05
3½ in. cap for wainscot	06
2 in. picture moulding	.06
4 in. chair rail	.07
3 ft. panelled dado, per sq. ft.	35
1 case of 3 drawers complete	8.00

Finishing Stock. White wood or cypress stock which has been moulded will cost one cent for every square inch of section a foot long, less a trade discount, which at present is 30 per cent off, so that a 5 in. casing will cost 5 cents per foot less 30 per cent, or 3½ cts. per foot.

Casings, 5 in.	$0.03½
Base, 8 in.	.05½
Plinth blocks, 5 in. x 8 in. x 1⅜ in.	.05
Corner blocks 5 in. x 5 in. x 1⅛ in.	.05
Mouldings $\frac{7}{10}$ cent per sq. in. of section	
Stock pattern stair rail 2½ in. x 2¾ in., per foot	.17
Balusters, 1⅜ each	.09
Newels, 5 in. stock pattern	5 00
Newels, 6 in. stock pattern	6.00
Plate rail and picture moulding per foot	.09
Picture moulding per foot	01½ to 03
Stock drawer case, 3 drawers	3.50
Panelled draw case, 5 drawers	13.00

Inside Doors five cross panels in pine to paint

2 ft. 8 in. x 6 ft. 8 in. x 1½ in.	$2.40
2 ft. 10 in. x 6 ft. 10 in. x 1½ in.	2.50
3 ft. 0 in. x 7 ft. 0 in. x 1½ in.	2 80

Window Frames

2½ ft. x 4½ ft.	$1 10
3 ft x 5 ft.	1.20

STAIRS

The trade of stair-building, while a part of the general work of joinery, is usually taken up as a separate trade and is done by men who do nothing else. For this reason it is better, if possible, to have the stairs figured and built by a regular stair-builder, who will have the special tools, moulds, and stock necessary for this branch of carpenter work.

There are usually in every house, two sets of stairs, one in the front part of the house and one in the back part. Sometimes the stairs are so arranged as to land together in the second story, but divide somewhere in their height upon a common landing, one part, the more ample and elaborate, running from the front hall, and the other from the back hall or kitchen. This is called a combination staircase and is often an economical solution of the problem of front and back stairs. See Fig. 14.

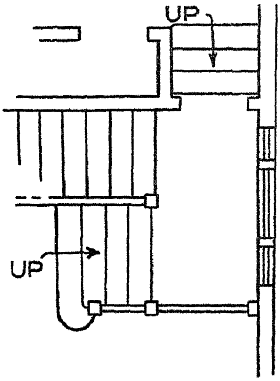


Fig. 14. Combination Staircase.

When two separate staircases are put in, each will have a distinct character, and it is this condition that we shall consider.

Front Stairs. The front stairs of ordinary width and elaboration, say from 3 ft. to 4 ft. wide with turned balusters and moulded rails and posts, in white wood or North Carolina pine, may be approximated at $3.50 to $4.50 per step, complete. This is on the basis $1.50 per step for labor, the remainder for the stock. Panelling in connection with the stairs should be figured at $.40 to $.50 per sq. ft. of which one-half will be labor and the other half the stock. For ash add 50 per cent, for oak 75 per cent.

Winding steps will cost about double the price of straight steps for material, but the labor will be increased only about 50 per cent. This price will allow of hard pine treads and plain moulded rail with 1½ in. turned balusters, two to a tread.

No more definite data can be given as to front stairs, as there is such a wide variation in design and finish, and such a wide range in selection of posts, rails, and balusters.

In general a good moulded and panelled newel may be had for $5.00 to $8.00, landing posts $3 00 to $4.00, rail 15 to 18 cents per lineal foot, balusters 9 to 12 cents each. Balusters turned in colonial pattern with an upper shaft, a square, and an urn-shaped turning at the base, will cost, turned to detail, about 18 cents; if twisted, add 30 cents. See Fig. 15.

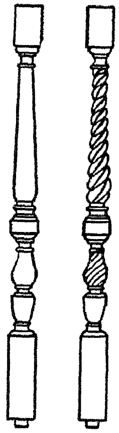


Fig 15 Balusters in Colonial Pattern

These prices are for open string stairs, if brackets are used on the outside stringer, it will add 12 to 15 cents per step.

Back Stairs. Common box stairs, for general use in the back and attic portions of a house, will cost about $1.60 per step, this includes 85 cents for stock and 75 cents for labor. Winders will be used more frequently here than in front stairs and will cost about double the price of a straight step. Open cellar stairs of plank with no risers will cost about 65 cents per step, giving 20 cents for labor and 45 cents for stock.

Summary. From the foregoing it will be found that a flight of front stairs in white wood will cost, at the average run of 16 steps, about $64.00; and the same in ash $96.00; in oak $112.00. This is a fair price for good plain work and will give a satisfactory result.

The back stairs at 15 steps would cost $24.00 and the cellar stairs $7.80. Under conditions where much of the handrailing could be done away with, the prices could be reduced considerably.

DAY'S WORK

A carpenter in one day can do any one of the following items:

400 running feet of plaster grounds

40 pairs of bridging

1 window, complete, frame, sash, and fittings

1 door, setting frame, hanging, casing, and fitting with hardware
Casing windows, 4 per day
Hanging and fitting blinds, 10 pairs per day
Hanging and fitting doors, 5 per day
Casing doors, 5 per day

Cost of labor per square of 100 feet:

Framing of floors, per square	$1.50
Framing of walls	1 50
Framing of plain roofs	1 50
Framing of hip and valley roofs	2.00
Heavy framing	1 20
Boarding walls	75
Boarding walls with matched boards	1 00
Boarding walls diagonally	1 00
Boarding roofs	1 00
Laying rough floor	.75
Laying rough floor diagonally	1 00
Bridging floors	50
Furring brick walls 12 in. on centers	1 50
Furring brick walls 16 in. on centers	1.00
Laying spruce upper floor, 6 in. stock	1 50
Laying spruce upper floor, 4 in. stock	2.00
Laying hardwood floors, 2½ in. stock	2.50
Shingling walls and roofs	2 18
Clapboarding walls	2.18
Papering walls under shingle or clapboards	.25

Work by the piece; labor:

Making window frames	$1.25
Making door frames	1.00
Door frame with transom	1.50
Setting window frames, each	.30
Setting window frames in brickwork, each	.50
Hanging blinds, per pair	.32
Fitting and hanging sashes per pair	.50
Hanging transoms	.40
Casing windows	.80

Large size windows	$1 50
Attic and cellar windows	75
Casing door opening, one side	.32
Casing door opening, both sides	.65
Fitting, hanging, and trimming door	65
Fitting, hanging, and trimming outside door	1 00
Pair of sliding doors, double	13.00
Work in common closet	1 50

Exterior Finish. The exterior finish of a house will consist, in the main, of the water table at the bottom, the belt midway, and the cornice at the top.

Prices of labor per lineal foot:

Water table, 3 members at 3 cents	$0 09
Corner boards	.03
Belt	.08
Cornice, 3 to 6 cents each member, or per ft.	.50
Gable finish, lineal foot	.60

Piazzas and Porches. An ordinary piazza will cost, complete, about 75 cents a square foot, making for an 8 ft. piazza a cost of $6.00 per running foot.

Shingled piazza columns each:

28 ft. boards at 2 cents	$0 56
11 ft. studding at 2½ cents	.28
1 bunch shingles	1 00
Nails	.13
Labor	4 00
	$5.94

Square cased columns 8 in. x 8 in. will cost, each:

Stock	$1.50
Labor	1.50
Erecting	.50
	$3.50

A simple balustrade of straight square balusters 1⅛ in. will cost per running foot:

Top rail	3 in. x 4 in.	$0 12
Bottom rail	2 ft. x 4 in.	.08
Balusters, four to a foot		.12
Labor		32
		$0.64

Piazza ceiling per square:

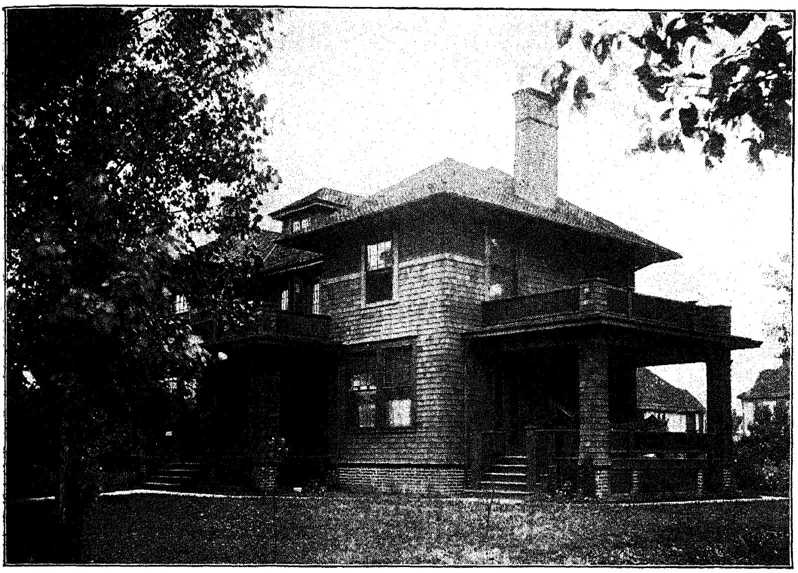
Sheathing	$4 00
Waste	1.25
Furring	1 50
Nails	25
Labor	1 50
	$8 50

Piazza Finish:

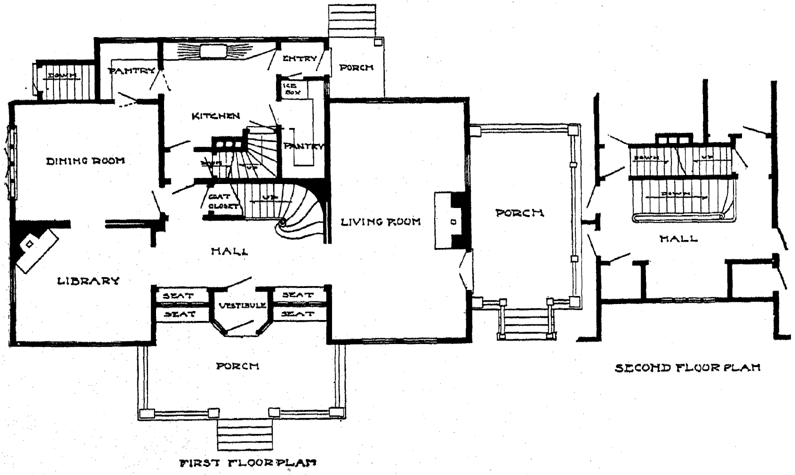
Stock pattern, 5 in. turned columns	8 ft. long	$ 2.00
Stock pattern, 6 in. turned columns	8 ft. long	2 75
Stock pattern, 8 in. Colonial columns	9 ft. long	3.50
Stock pattern, 10 in. Colonial columns	9 ft. long	5 50
8 in. Doric Column from detail	9 ft. long	6.50
10 in. Doric Column from detail	9 ft. long	8.50
10 in. Fluted Column from detail	9 ft. long	15.00
Short Posts, 5 in. x 5 in. x 4 ft. 0 in.		1.00
Short Posts, 6 in. x 6 in. x 4 ft. 0 in.		1 50
Piazza balusters 1¾ in., 14 in. to 16 in. long, .06 to		.10
Piazza rail 1¾ x 3¾ in. per ft.		.06
Piazza rail 2¼ x 3¾ in. per ft.		.07
Tin roof per square		10 00 to 12.00

Conductors:

15 ft. pipe at 15 cents	$2 25
Gooseneck and labor	.65
Putting up	.50
	$3.40



HOUSE IN URBANA, ILL.
White & Temple, Architects, University of Illinois
Walls and Roof Shingled. Cost, $5,000-$5,500. View Taken from Southwest.
For Interiors, See Page 203.



FIRST FLOOR PLAN

SECOND FLOOR PLAN

PLANS OF HOUSE IN URBANA, ILL.

HARDWARE

The best way to get at the cost of hardware is to get a schedule nd price for each job from the dealer. The price of hardware s constantly changing. Prices are given here for a few staple articles f ordinary value.

Nails per cwt.	$2 50 to $4 00
Front door set (bronze metal)	7 00 to 10.00
Vestibule door set	6.00 to 8.00
Inside door set	1 00 to 1 50
Store door set	6.00 to 10 00
Single sliding door set	1.50 to 2.00
Double sliding door	2 00 to 3.00
Double acting floor hinge per pair	3.50 up
Double acting spring hinge "	2 00 up
Window fixture, weights, etc.	1.10 up
Sash fast each	.25 to .35
Transom fixture	.30 to .50
Cupboard door set	.60
Folding door bolts	1.25 to 3.00
Flush bolts per pair	1.50
Butts, small size per pair	.25
Butts, ordinary size, per pair	.30 to .40
Double coat and hat hooks, per dozen	2.50
Screws, per gross, bronze	.85
Single sliding door hanger	2 50 to 3.75
Double sliding door hanger	3.50 to 5.50

NAILS

Nails are priced from a base price per hundred weight adopted by the manufacturers, which includes certain sizes of the more common kinds. From this base the different kinds of nails are priced by means of extras, as agreed upon. The present base includes common, fence, and sheathing nails in sizes from 20 penny to 60 penny.

Following is a schedule of all kinds of cut and wire nails in general use and the extra price of each kind per cwt. above the base, which is $2.50 per cwt., for cut nails and $2.45 per cwt. for wire nails.

National List of Extras per cwt. for Cut Nails in Fair Assortment. Adopted Dec. 1, 1896

Common, Fence, and Sheathing	
Base 20d to 60d	$2.50*
(* Variable July, 1907, $2 65)	
	Extras
10d to 16d	$0 05
8d and 9d	.10
6d and 7d	20
4d and 5d	.30
3½d	.40
3d	.45
3d fine	.65
2d	.70
Spikes, all sizes	.10

Casing, Box, and Floor	
10d and larger	$0 15
8d and 9d	25
6d and 7d	35
4d and 5d	.50
3d	.70
2d	1 00

Slating	
6d	$0.40
4d and 5d	.50
3d	.75
2d	1.00

Fine Finishing	Extras
10d and larger	$0.25
8d and 9d	35
6d and 7d	.45
4d and 5d	.65

Barrel, Roofing, and Cottage	
1½ inch	$0 30
1⅜ inch	.40
1¼ inch	.50
1⅛ inch	.60
1 inch	.70
⅞ inch	.85
¾ inch	1.00

Clinch	
3 in. and larger	$0.45
2¾ and 2½ in.	.55
2¼ and 2 in.	.65
1¾ and 1½ in.	.75
1¼ in.	.95
1 in.	1 15

10 cents for each ½ keg

4d Swedes Genuine	$1.30
4d Swedes Common	.80
Galvanizing	2½ cts. per lb.
Timing	3 cts. per lb.

Size	2d	3d	3½d	4d	5d	6d	7d	8d	9d	10d
Length	1	1¼	1⅜	1½	1¾	2	2¼	2½	2¾	3

Size	12d	20d	30d	40d	50d	60d
Length	3½	4.	4½	5	5½	6

WIRE NAILS

Adopted Dec. 1, 1896.

Common, Fence, and Flooring

Base 20d to 60d	$2.45*

* (Variable. July, 1907, $2 55.)

	Extras
10d to 16d	$0.05
8d and 9d	.10
6d and 7d	.20
4d and 5d	.30
$3\frac{1}{2}$d	.40
3d	.45
3d fine	.50
2d	.70

Barbed Common and Barbed Car Nails

15c. advance over common

Slating

2d	$0.80
3d	.60
4d and 5d	.40
6d	.30

Casing and Smooth Box

10d and larger	$0.15
8d and 9d	.25
6d and 7d	.35
4d and 5d	.50
3d	.70
2d	1.00

Barbed box, 15 cts. advance over smooth

Smooth Finishing Nails

	Extras
10d and larger	$0.25
8d and 9d	.35
6d and 7d	.45
4d and 5d	.65
3d	.85
2d	1.15

Barrel

$\frac{3}{4}$ in.	$1.00
$\frac{7}{8}$ in.	.85
1 in.	.70
$1\frac{1}{8}$ in.	.60
$1\frac{1}{4}$ in.	.50
$1\frac{3}{8}$ in.	.40
$1\frac{1}{2}$ in.	.30

Clinch Nails

2d	$1.05
3d	.85
4d and 5d	.65
6d and 7d	.55
8d and 9d	.45
10d	
12d and 16d	.35
20d	

Wire Spikes

All sizes	$0.10

MISCELLANEOUS DATA

Broken stone filling cu. yd.	$ 2.50
Cesspool 6 ft. diam. and 8 ft. deep, 8 in. brick	60.00
Blind drains per lineal ft.	.12

Earthen drains 4 in. diam. per foot	$ .20
Arch brick laid in wall per M.	100 00
Marble mosaic per sq. ft.	.75
Marble threshold, exterior	5.00
Marble base per foot	.50
Granolithic per sq. ft.	.25
Steel beams per lb.	.03
Cast iron per lb.	.02
Copper skylights per sq. ft, heavy	1.75 to 2 50
Plastering 2 coats on wire lath	.65
Wooden balustrade per ft.	1.50
Outside blinds for a house will average per pair	85
Inside doors, 5 cross panels, pine to paint, average	3 25
Store sash $1\frac{3}{4}$ in. per lineal foot	.30
Storm sash for house will average	1.55
Outside door frame with transom	3 50
Inside door frames will average	1.10
Same with transoms	1.85
Factory window complete 4 ft. 0 in. × 8 ft. 0 in.	13.00
Framing heavy lumber per M.	12.00
Planing lumber per M.	2.00
Laying plank floors per M.	9 00
Common bricks per M.	9 00
Common bricks laid in wall per M.	20 00
Concrete foundations per cu. yd.	7.25
Shingling on roof per square	6.54
Slating	11.80
Tar and gravel roof per square	6.00
Tin roofing per square, average	11.00

ROOFING

Description. Many kinds of material are used for covering roofs, depending upon the nature of the work, the pitch of the roof, the desired appearance, and the availability of material.

Shingles. The roof covering of an ordinary wooden house is generally of shingles. These are either shaved or sawed, but sawed shingles are generally used. Sawed shingles come in bundles of 250, or four bundles to the thousand. These quantities are based on a width of 4 in. to each shingle so that if they are wider they will be numerically less and consequently, if narrower, there will be more in number. Common shingles are 16 in. to 18 inches in length.

Measuring. In measuring for shingles the quantities are usually taken by the square; equal to 100 sq. ft., and the number of shingles required will depend upon the lap or exposure which is given to the shingles. On roofs the exposed length is usually 4½ inches, and on walls 5 or 6 inches is the usual exposure, although in the carrying out of special designs a greater or less exposure may be given.

Quantities. The covering capacity of 1000 shingles at various exposures is as follows:

4 inches to the weather	111 sq. ft.	= 900 per square
4½ inches to the weather	125 sq. ft.	= 800 per square
5 inches to the weather	139 sq. ft.	= 720 per square
6 inches to the weather	167 sq. ft.	= 600 per square
7 inches to the weather	194 sq. ft.	= 514 per square
8 inches to the weather	222 sq. ft.	= 450 per square

Cost. Sawed cedar shingles of best quality marked "Extra" will cost from $4.00 to $5.00 per thousand, and clear shingles, that is, having the exposed lower third of clear stock, will cost $3.50 to $4.00 per thousand, and it will require 5 pounds of 4 penny nails. These will cost 3 cents a pound if plain, or 5 cents, galvanized.

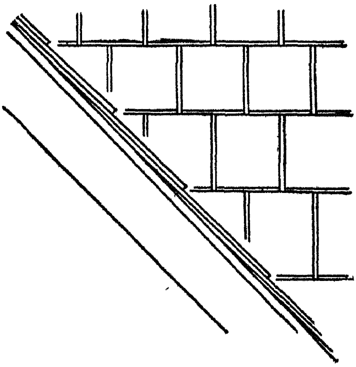


Fig. 16 Slating.

A carpenter in one day of 8 hours will lay 1500 shingles on plain work or 1000 if surface is much cut up. This will cost at $3.20 per day from $2.14 to $3.00.

In estimating shingling an allowance will be necessary for waste; this should be about 5 per cent on plain roofs and 8 to 10 per cent on roofs with many hips, valleys, or dormers.

Slating. Slates are made in different sizes from 6 x 12 up to 16x24 and larger sizes for special work. They are laid with reference to head-cover rather than exposure, that is: the lap of cover of each course by the second above it, gives the gauge to which slates should be laid, Fig. 16; this lap is usually 3 inches, so that the exposed length of any slate may be found by subtracting this lap from the length of the slate and dividing by 2. This exposure multiplied by the width of the slate gives the exposed area of the slate, and the number of slates in a given area may be found by dividing the area in square inches by the exposed area of the slate.

Example. How many slates will be required per square to cover a roof if 8-in. x 14-in. slates are used?

$$\frac{(14 \text{ in.} - 3 \text{ in.})}{2} = 5\tfrac{1}{2} \text{ in.}; \; 8 \text{ in.} \times 5\tfrac{1}{2} \text{ in.} = 44 \text{ sq. in.}, \; \frac{14400 \text{ sq. in.}}{44 \text{ sq. in.}} = 327.$$

In measuring a slate roof it is usual to allow an extra width of from 6 inches to a foot, according to localities, on hips, valleys, eaves, and wall cuttings, to allow for the extra work involved.

Extra charge should be made for towers and all varied forms of roof.

Quantities. The number of slates required to cover a square of roofing is given for various sizes in the following table:

6 x 12	533	10 x 20	165
7 x 14	377	11 x 22	138
8 x 16	277	12 x 24	114
9 x 18	214	14 x 28	83

The cost of slating per square is as follows:

Slates	10 in. x 16 in.	$ 7.50
Labor 1 day, slater		3 50
Nails		.15
Roofing paper		.50
Labor on paper		15
		$11.80

Tin roof per sq. ft., average	$0.11
Gutters per ft., galv. iron	90
Galv. iron conductors per ft., put up	.18 to .25
Copper roof, plain per square	40.00
Copper roof, with battens per square	50 00
Gravel roofing, 5-ply per square	6 00

Zinc flashing, 1½ cent per inch of width, per foot.

Tiles. Where a special feature is to be made of the roof, tiles are often used but these are found in such a variety of shapes, sizes, and prices, that a roof of this sort should always be given to a roofer to estimate.

Metal Roofs. Copper or tin is generally used for roofs where a metal covering is desired. Copper roofs, if steep enough to show as a feature of the building, are usually laid with ribs over battens. This makes a handsome and durable roof the cost being not greatly increased.

Copper roofing will cost from $35.00 to $40.00 per square.

Flashings around skylights and balustrades, 30 to 50 cents a lineal foot.

For a cheaper metal roof, tin is generally used; this may be used on steep or flat roofs. Tin for roofing should be painted on the under side and carefully soldered on the top.

Tin roofing will cost from $10.00 to $12.00 a square.

Composition Roofs. For flat roofs, a composition of tar and paper in layers finished with a protective coat of gravel, is often used; the cost of this depends upon the number of layers of paper and "moppings" of tar required, but a 5-ply roof will give good service and will cost about $6.00 a square.

Gutters and Conductors. Gutters and conductors are both made of wood or metal, metal being preferred in all cases. For metal gutters copper and galvanized iron are used.

Copper gutters will cost about	$1.25 a lineal foot.
Copper conductors	.50 to .75 a foot
Goosenecks	5 00 to 10 00 each
Moulded conductor heads	4 00 to 10 00 each
Straps	1 00 each

Galvanized iron gutters will cost about 90 cents a lineal foot, and conductors, 18 to 25 cents a foot according to size.

PLASTERING

Plastering is measured by the square yard and is usually done in 2-coat or 3-coat work. In taking off plastering it is customary to deduct only one-half of the area of openings to allow for the extra work of plastering to the grounds.

In some localities no openings are deducted unless more than 7 yards in area, but in close figuring this is not generally followed.

Narrow strips, such as chimney breasts, if less than a foot wide, are generally called a foot. Round corners, beads, and arrises must be taken separately by the lineal foot.

Raking surfaces require additional work and should be taken at about one-half more than plain work. Circular or elliptical work should be charged at two prices and domes, groins, and intersecting soffits, at three prices. Cornices are taken by the square foot of girth with enrichments charged separately by the lineal foot.

Lathing. Lathing is generally included in the plasterer's price although put up by a different set of men. Lathing is estimated by the square yard or by the thousand laths, the price being $2.75 to $3.25 a thousand.

Labor. Two plasterers requiring one helper will do from 40 to 50 square yards of three-coat plastering, or 60 to 70 square yards of two-coat work, in a day of 8 hours, and 1,200 to 1,500 laths makes a day's work for one lather. 100 sq. yds. of lath and plaster will cost about as follows, for two-coat work:

1,500 laths at $4.75 per M	$ 7.12
10 lbs. 3d. nails at $3.20 per cwt.	.32
Labor on laths	4.50
10 bushels lime at .48 per bu.	4.80
6 lbs. hair at .04	.24
1 load sand	1 80
Plasterer 3 days at $5.00	15.00
Helper 1½ days at $3.00	4.50
Cartage	1.00
	$39.28

Cost of a square yard of two-coat work, $39.28 ÷ 100 = 39 to 40 cents.

This is a price which is on the increase and, while plastering is done in the country towns as low as 35 cents per yard it will not be safe to use this price any length of time.

For three-coat work we may take the following schedule:

Laths and putting on, as above	$11.94
13 bush. lime at .48	6.24
8 lbs. hair at .04	32
1½ loads sand at $1.80	2.70
1 bbl. plaster Paris	1.70
Plasterer 4 days at $5.00	20.00
Helper 2 days at $3.00	6.00
Cartage	1.00
	$49.90

Cost of a sq. yd. of three-coat work, $49.90 ÷ 100 = 50 cents.

Rules. In some portions of the country a set of rules has been adopted governing the valuing of plasterer's work which are in the main as follows:

"*First.* Measure on all walls and ceilings the surface actually plastered, without deducting any grounds or any openings of less extent than seven superficial yards.

Second. Returns of chimney-breasts, pilasters, and all strips of plastering less than twelve inches in width, measure as twelve inches wide; and where the plastering is finished down to the base, surbase, or wainscoating, add six inches to height of walls.

Third. In closets, add one-half to the measurement. Raking ceilings and soffits of stairs, add one-half to the measurement; circular or elliptical work, charge two prices; domes or groined ceilings, three prices.

Fourth. For each twelve feet of interior work done farther from the ground than the first twelve feet, add five per cent; for outside work, add one per cent for each foot that the work is done above the first twelve feet."

Stucco-work is generally governed by the following rules; viz., "Mouldings less than one foot girt are rated as one foot, over one foot, to be taken superficial. When work requires two moulds to run same cornice, add one-fifth. For each internal angle or mitre, add one foot to length of cornice, and, for each external angle, add two feet. All small sections of cornice less than twelve inches long measure as twelve inches. For raking cornices, add one-half; circular or elliptical work double price; domes and groins, three prices.

For enrichments of all kinds a special price must be charged. The higher the work is above ground, the higher the charge must be; add to it at the rate of five per cent for every twelve feet above the first twelve feet."

PAINTING

Painting is estimated by the yard, doors and windows being taken solid to make up for the extra labor of cutting in the sashes and mouldings.

Railings, fences, grilles, and similar surfaces are taken solid.

A painter in one day will cover 100 yds. of outside work one priming coat, or 80 yds. of the second coat. Ten pair of blinds will make a day's work.

On first coat, one pound of paint will cover about 4 sq. yds. and 6 sq. yds. on the subsequent coats. One pound of putty for stopping will cover 20 yds.

Shingle stains require a gallon for every 500 shingles if dipped two-thirds in, and for a brush coat after laying, a gallon will cover about 200 feet of surface, or 1500 shingles.

1 gallon of priming color	will cover 50 yards
1 gallon of zinc white	will cover 50 yards
1 gallon of white paint	will cover 44 yards
1 gallon of black paint	will cover 50 yards
1 gallon of stone color	will cover 44 yards
1 gallon of yellow paint	will cover 44 yards
1 gallon of green paint	will cover 45 yards
1 gallon of emerald green	will cover 25 yards
1 gallon of bronze green	will cover 75 yards

The following table gives the comparative covering of paints by weight on various surfaces.

COVERING OR SPREADING POWER OF TYPICAL PAINTS* ON WOOD

	FIRST COAT	SECOND COAT
Red lead	112	252
White lead	221	324

---

*The figures represent square feet covered by 100 lbs. of paint of the usual consistency, applied evenly with a brush.

	First Coat	Second Coat
Oxide of zinc	378	453
Red oxide	453	540
Raw linseed oil	756	872
Boiled linseed oil	412	540

ON METAL

Red lead	477	
White lead	648	
Oxide of zinc	1134	
Red oxide	870	
Raw linseed oil	1417	
Boiled linseed oil	1296	

ON PLASTER

Red lead	324	
White lead (on sized wall)	362	
Oxide of zinc	594	
Raw linseed oil (unsized wall)	55	99

Cost. The cost of painting varies under different conditions but in general the following table will be found an average price:

INSIDE WORK

1 coat per sq. yd.	$0.12
2 coats per sq. yd.	.20
3 coats per sq. yd.	.25
1 coat shellac per sq. yd.	.10
1 coat size and 2 coats paint	.20
1 coat size and 3 coats paint stipple	.30

INSIDE FINISH

1 coat liquid filler, 1 coat varnish	$0 20
1 coat " filler, 2 coats varnish	.25
1 coat " filler, 3 coats varnish	.30
1 coat paste filler, 1 coat varnish	.25
1 coat " filler, 2 coats varnish	.30
1 coat " filler, 3 coats varnish	.35

Tinting walls in distemper will cost 15 cents per sq yd. for small amounts and 10 cents per sq. yd. for 50 yds. or more. Finishing hard wood floors with filler, shellac, and 2 coats of varnish or wax finish will cost 30 cents per sq. yd.

OUTSIDE PAINTING

1 coat new work per sq. yard	$0.10
2 coats new work per sq. yard	.18
3 coats new work per sq. yard	.25

SANDING

2 coats paint, 1 coat sand per sq. yd.	$0.28
3 coats paint, 1 coat sand per sq. yd.	.35
3 coats paint, 2 coats sand per sq. yd.	.50

Painting on brick will cost 12 cents per yard for the first coat, but subsequent coats will cost no more than on wood. Tin roofs can be painted one coat for 5 cents a yard.

1000 shingles dipped two-thirds of their length will cost $3.00 and a brush coat in addition costs 50 cents. Blinds are rated at $1.50 per pair for an average size.

HEATING

The heating of a building is generally made the subject of a special contract.

The three usual methods for house heating are, the Hot Air Furnace, the Hot Water Boiler, or the Steam Boiler. Sometimes a combination system of hot air and steam, or hot air and hot water is used.

Estimates of the cost of heating should be obtained from contractors who follow this particular branch of construction.

In general, for an ordinary class of building such as residences, apartments, stores, etc., the heating will range according to the system used, from 6% to 12% of the cost of the building, as follows:

Hot air furnace	6 to 7 per cent.
Steam	8 to 10 per cent.
Hot water	10 to 12 per cent.

These figures are approximate and the only reliable way to obtain the actual cost is by taking off the items and figuring each job by itself.

Quantities. The hot air heating of an ordinary house can be approximated closely by the builder on the basis of cubic contents to be heated; and the area of piping and capacity of the furnace can be approximated by means of the following general rules:

To determine the size of pipe for any room, find the cubic contents of the room in cubic feet and divide this by 25 for rooms on the first floor, and by 35 for rooms on the second and third floors.

Make the cold air box at least ¾ of the combined area of pipes, none of which should be smaller than 7 inches in diameter.

Example. For a small house of seven rooms the quantities may be as follows:

FIRST FLOOR

Parlor 12 x 15 x 9 ft. high 1624 cu. ft. divided by 25 = 65 sq. in. or 9 in. pipe

Hall 8 x 20 x 9 ft. high 1440 cu. ft. divided by 25 = 58 sq. in. or 9 in. pipe

Add 40% for second story hall space making 81 sq. in. = 10 in. pipe

Dining Room 14 x 15 x 9 ft. high 1890 cu. ft. divided by 25 = 76 sq. in. or 10 in. pipe

SECOND FLOOR

Chamber 13 x 15 x 8½ = 1658 cu ft. ÷ 35 = 48 sq. in. or 8 in. pipe
Chamber 11 x 12 x 8½ = 1122 cu. ft. ÷ 35 = 32 sq. in. or 7 in. pipe
Chamber 14 x 16 x 8½ = 1904 cu. ft. ÷ 35 = 55 sq. in. or 8 in. pipe
Bath Room 8 x 10 x 8½ = 680 cu. ft. ÷ 35 = 20 sq. in. or 7 in. pipe

Total pipe area:

2 - 10 in. pipes 78 sq. in. each	156 sq. in.
1 - 9 in. pipe 64 sq. in.	64 sq. in.
2 - 8 in. pipes 50 sq. in.	100 sq. in.
2 - 7 in. pipes 38 sq. in.	76 sq. in.
Total pipe area	396

From this scale we can determine the size of the furnace and the cost of piping.

A furnace to carry say 400 to 500 sq. feet of pipe area would cost, set in place, from $100 to $125. The labor on pipes, registers, and furnace $20 to $24.

The cost of piping will depend on the distances to run but the material can be estimated as follows:

Round tin pipes will cost; from A. A. charcoal plates, as follows:

Size of Pipe	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	18″
Per Foot	09	10	.12	.14	.16	.18	.23	25	27	28	.30	.32
Hot Air Damper.	.12	.12	12	15	15	.15	.18	.18	18	20	20	.25
Furnace Collars	10	.10	.10	.12	.12	14	.18	18	18	20	.20	.25
Tin Elbows	12	.15	.18	.20	25	30	35	40	45	.50	60	70

*REGISTERS

Size	6x10	7x10	8x10	8x12	9x12	10x14	12x15	12x16	14x18	16x20
Black Register	50	52	.52	58	.64	1 08	1 37	1.70	2 74	3 75
Slate Stone	.38	.42	.44	.50	.63	.70	.93	1.00	1.50	2 35
Register Box	.14	.16	.17	.20	.23	.27	.33	35	.38	.50
Netting	.05	.05	.06	.06	07	.07	.08	.08	.10	.12
Totals	1 07	1 15	1.19	1 34	1.57	2.12	2 71	3 13	4.72	6 72

*July, 1906.—Add one-third.

Galvanized smoke pipe will cost 9c per lb. and will weigh per lineal foot as follows:

Size No.	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″
22	1¾	2⅛	2⅝	3	3⅜	3¼	4⅛	4½	5	5¼	5¾
24	1¼	1⅝	1⅞	2⅛	2½	2¾	3	3⅜	3⅝	3⅞	4¼

GALVANIZED ELBOWS

Size	4″	4½″	5″	5½″	6″	7″	8″
Pound	1	1¼	1½	1¾	2¼	2¾	3¼
Cost	18	20	23	.25	28	.32	.35

Tin, per Sheet

DC	12½ x 17	.05
IX	14 x 20	.07
IXX	14 x 20	.08
IX	20 x 23	.12
IX	20 x 26	.13
IX	20 x 29½	.16
IX	20 x 32½	.17

Miscellaneous Data

Galvanized sheet iron per lb.	$0.05
Common sheet iron per lb.	.04

Zinc per lb.	$0 10
Wrought iron per lb.	04
Galvanized piping per lb.	09
Galvanized cold air box per lb.	.09
Galvanized furnace shields per sq. ft.	.08
Register box netting per sq. ft.	.05
Asbestos paper at 1½ lbs. per sq. yd.	.05

Figure cold air supply ¾ combined area of piping.

Register grilles take up ⅓ of area of register.

Locate registers nearest convenient point to furnace, inside part of room preferred. Locate furnace so that all pipes will be as nearly equal in length as possible.

Estimate pipes by lineal foot, but elbows and dampers separately, also registers with boxes and borders.

Allow from $1.00 to $1.25 for flange connection of cold air box to furnace casing.

Cover all risers with asbestos paper in partitions.

HOT WATER AND STEAM HEATING

In estimating for heating with hot water, all pipes and fittings must be taken off and listed, all standard radiators priced by the square foot of radiation, and special radiators listed separately, also tanks, valves, hangers, etc.

Radiators are listed in the trade catalogues, together with the number of square feet in each section.

These prices are subject to varying discounts which can be obtained of the manufacturers.

Radiation. The amount of radiation necessary for each room depends upon so many varying conditions that all rules are in a way approximate.

Certain formulae may be used, which will give good results in ordinary cases, but just what allowances are necessary must be determined by the heating engineer.

The same is true of making the estimates of hot water or steam and the contractor should in all cases have the job figured by an expert.

In ordinary cases the amount of radiation may be determined from the cubic contents of the rooms to be heated by the following tables which give the proportions of one square foot of radiating surface to the cubic contents of the various rooms in cubic feet.

STEAM

One Square Foot of Radiation Will Heat	Dwellings, Cubic Feet	Halls, Stores, Etc. Cubic Feet	Churches and Auditoriums, Cubic Feet
By direct radiation—			
On first floor	35 to 60	75 to 100	125 to 200
On upper floors	50 to 80	....	....
By indirect radiation—			
On first floor	25 to 40	50 to 70	80 to 135
On upper floors	40 to 50	.. ..	....

HOT WATER

One Square Foot of Radiation Will Heat	Dwellings, Cubic Feet	Halls, Stores, Etc Cubic Feet	Churches and Auditoriums, Cubic Feet
By direct radiation—			
On first floor	15 to 25	30 to 45	50 to 85
On upper floors	25 to 40		
By indirect radiation—			
On first floor	17 to 40	45 to 65	80 to 125
On upper floors	25 to 35		

Having determined the amount of radiation, piping, and fittings, the labor may be obtained by adding about 20 per cent to the cost of materials.

PLUMBING

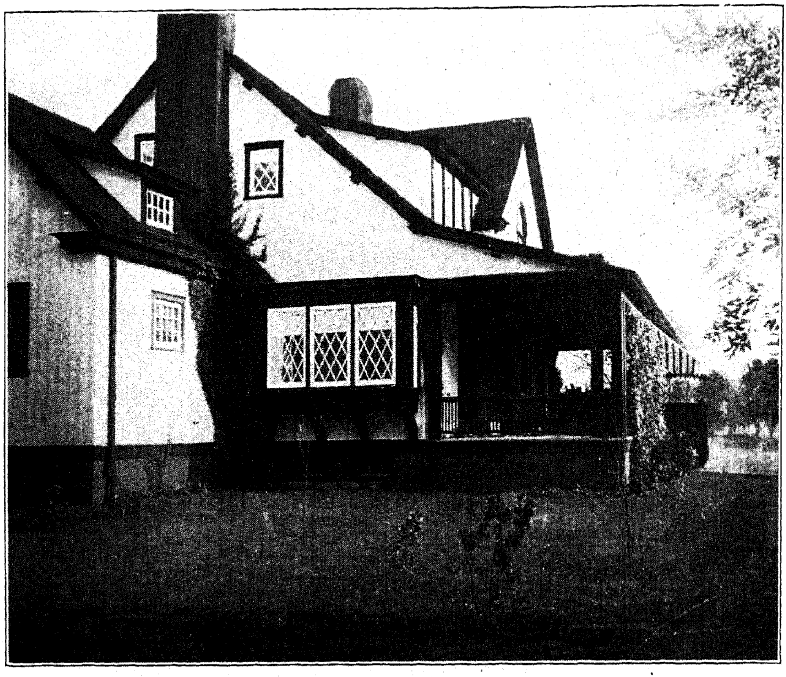
So wide a range is possible in the selection and price of plumbing fixtures that no very useful data can be given for a complete installation.

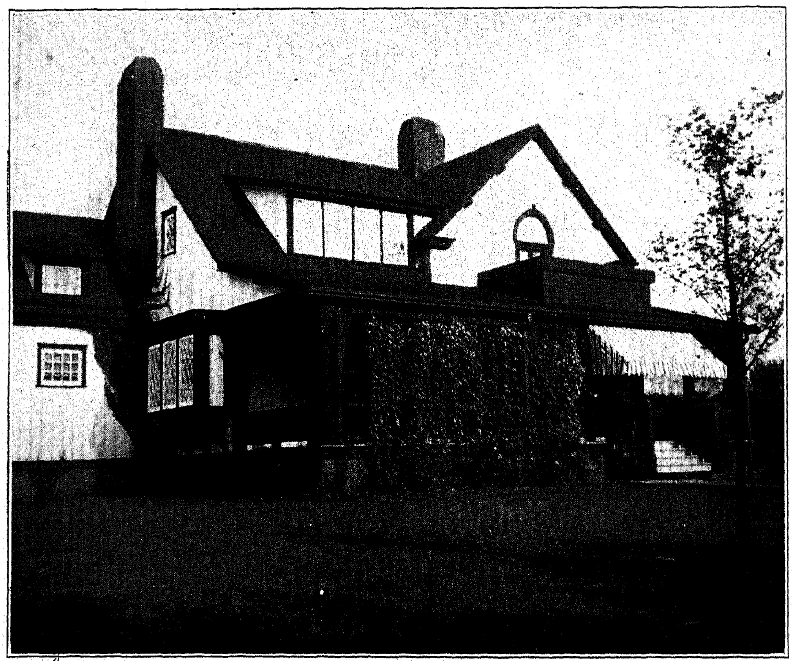
For instance, in one house the price of a single bathroom, fitted up to meet the fancies and purse of the owner, may cost more than the whole plumbing outfit of his more modest neighbor.

Nevertheless, it is a fact that the plumbing of a house is a poor place to practice economy, as no part of the construction of a building needs more careful attention in execution or in selection.

In general, a good job of plumbing will cost about 10 per cent of the cost of the building, and of this outlay about 30 per cent will represent the labor.

In taking off plumbing the contractor should begin at the sewer

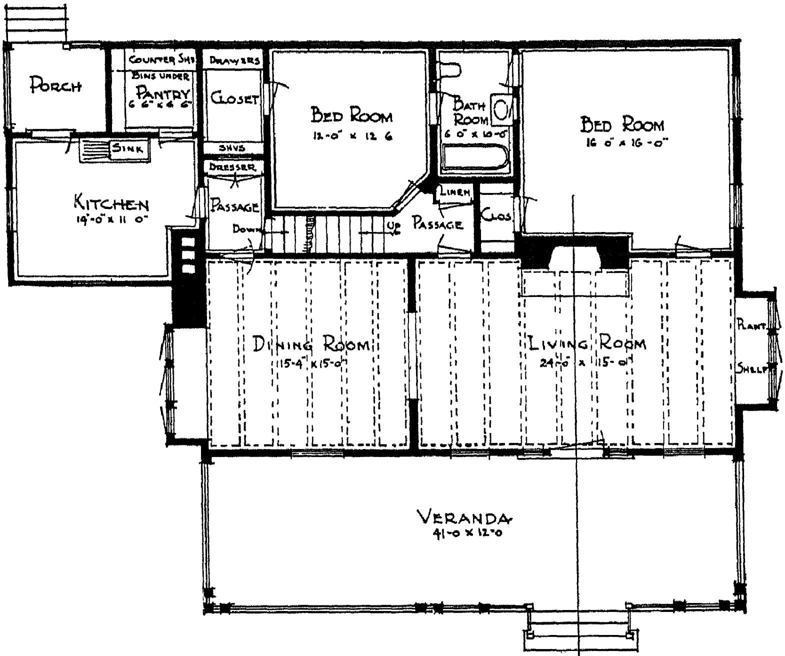




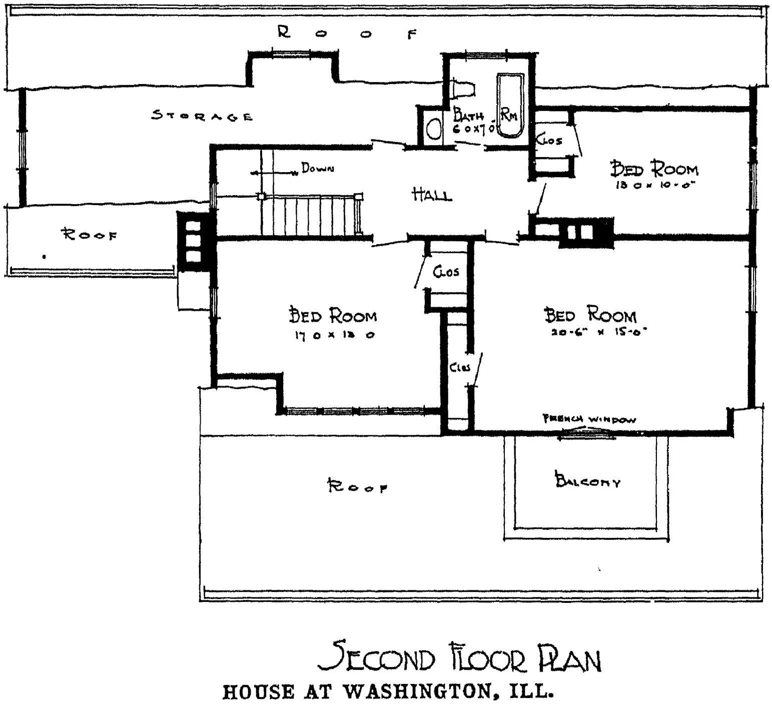
HOUSE AT WASHINGTON, ILL.

Herbert Edmund Hewitt, Architect, Peoria, Ill.

Walls of Cement on Metal Lath. Roofs Covered with Shingles Stained Green. All Outside Woodwork Stained Dark Brown. No Paint on Outside except on Sash.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

HOUSE AT WASHINGTON, ILL.

Herbert Edmund Hewitt, Architect, Peoria, Ill.

Built in 1904. Cost, about $4,500. House was Built for a Summer House, but Constructed the Same as if for All Year-Round Use, and Provided with Heating Plant.

or cesspool, if the drains are included, or, if not, at the outer end of the soil pipe, and take off carefully every pipe with its fittings, which should be itemized carefully as this data will be useful in getting at the amount of caulking, fitting, etc.

Soil Pipes. Soil pipes should be estimated by the lineal foot, allowing in each joint ¾ of a pound of lead for every inch in diameter of the pipe.

List prices of pipe and fittings can be obtained from the dealers, which are subject to discount; these vary from time to time, but the present discounts will be found to bring the prices of the more common materials about as follows:

DRAINAGE

4-in. extra heavy soil pipe per ft.	$ .30
3-in. extra heavy soil pipe per ft.	.22
2-in. extra heavy soil pipe per ft.	.15½

For fittings add 35 per cent to the cost of pipe.

4-in. running trap	2.00
4-in. brass ferrule cleanout	.50
4-in. lead bend	1.50
4-in. brass ferrule	.50
2-in. brass ferrule	.20
Solder per lb.	.22

WATER SUPPLY

40 gal. galvanized boiler and stand	$15.00
1-in. brass pipe per ft.	.60
1-in. galvanized pipe per ft.	.09
¾-in. galvanized pipe per ft.	.06
½-in. galvanized pipe per ft.	.05
1-in. stop and waste cock	1.50
¾-in. stop and waste cock	.90
½-in. stop and waste cock	.80
Sill cock	1.00

For fittings, add 30 per cent to cost of pipes.

WATER

1 cu. ft.	7.48 gallons
1 cu. ft.	29.92 quarts

1 cu. ft., 62.321 lbs.	1004 oz.
1 cu. yd.	1692 lbs.
1 gal., 231 cu. in.	8⅓ lbs.
1-foot cylinder	49 1 lbs.
1-inch cylinder	.028 lbs.

Pressure per sq. in. = depth in feet x 433.

Each 27.72 inches of depth gives a pressure of 1 lb. to a square inch.

A barrel 31½ gal.

Contents in cu. ft. x 2375 = barrels.

Head of water = pressure in lbs, per sq. in. x 2.31.

Number of gallons in a foot of pipe = Diam. in. inches 2 x .04.

Supply for one person is 15 gallons a day.

Actual use 6 gallons to 12 gallons.

Water 34 feet high has a pressure of 15 lbs. per sq. in. equal to atmosphere.

CAPACITY OF CISTERNS

In Gallons, for Each Foot in Depth

DIAMETER IN FEET	GALLONS	DIAMETER IN FEET	GALLONS
2.	23 5	9	475.87
2 5	36 7	9.5	553.67
3.	52.9	10.	587.5
3.5	71 96	11.	710 9
4.	94.02	12.	846.4
4 5	119.	13.	992 9
5.	146.8	14.	1,151.5
5 5	177.7	15.	1,321.9
6.	211.6	20	2,350.0
6.5	248.22	25.	3,570.7
7.	287.84	30.	5,287.7
7.5	330.48	35.	7,189.
8.	376.	40.	9,367.2
8.5	424.44	45.	11,893.2

The American Standard gallon contains 231 cubic inches, or 8⅓ pounds of pure water. A cubic foot contains 62.3 pounds of water, or 7 48 gallons Pressure per square inch is equal to the depth or head in feet multiplied by .433. Each 27.72 inches of depth gives a pressure of one pound to the square inch.

For tanks that taper, take diameter $\frac{4}{10}$ from large end.

FIXTURES

3-ft. soapstone sink complete	\$30.00 to \$40.00
14-in. x 17-in. lavatory with marble slab and back piece fitted complete	\$35.00 to \$50.00

Enamelled iron lavatory complete	$25.00 to $40.00
5-ft. 6-in. enamelled iron bath complete	$60.00 to $100 00
Bath tub only	$25 00 to $35 00
Soapstone laundry trays complete	
One part	$15.00 to $18.00
Two parts	$30 00 to $35.00
Three parts	$45.00 to $60.00

List prices of fittings may be obtained from all dealers, subject to large discounts, which should be considered frequently as they are constantly changing.

Labor. Having made a complete list of pipe, fittings, and fixtures, the labor of construction of an ordinary job of plumbing will run from 20 to 40 per cent of the cost of materials.

GAS FITTING

As in plumbing so in gas fitting, the wide range of selection and cost in fixtures, makes it impossible to give satisfactory data in regard to cost.

The piping only, of an ordinary house will cost from $1.75 to $2.00 an outlet, and the whole outfit should cost from 3 to 5 per cent of the cost of the house.

Pipes of usual size cost as follows:

⅜-in. gas pipe per foot	$0.03
½-in. gas pipe per foot	.04
¾-in. gas pipe per foot	.05
1½-in. main	.08

Fittings 25 per cent of cost of pipe.

ELECTRIC WORK

The original contract for a house usually provides for the wiring for electric lighting and bells, but fixtures are generally left to be provided for by a later agreement, as there is such a great latitude in selection and cost.

For electric light wiring one of two systems is usually employed: the conduit system, where the wires are all run in pipes or conduits, and the knob and tube system, where the wires are run in the clear space between timbers, secured to porcelain knobs, or passing through short tubes of the same material.

In general, the rough wiring of a house may be reckoned at $4.00 per outlet for conduit work, and $2.00 per outlet for knob and tube work.

This is for every time the wires are brought to the surface, whether for switches, cutouts, or fixtures Another way is to allow $1.50 for each lamp or switch.

Switches. Various kinds of switches are used, the two principal kinds being the push button, and the rotary switch.

These vary in price according to make and finish.

A good rotary switch can be had at from 90 cents to $1.00.

Push button switches from $1.00 to $1.10.

Snap switches from 30 to 40 cents.

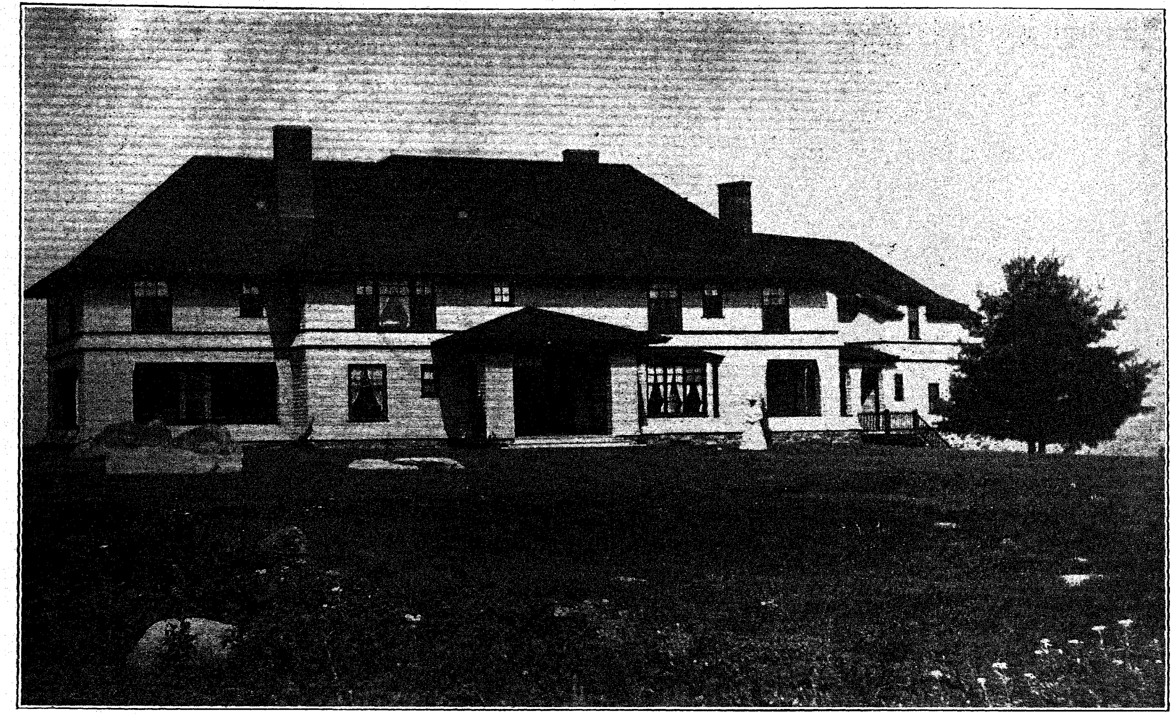
Wires are sold in coils which are marked with the gauge and manufacturer, and should bear the label of inspection acceptable to the local Insurance board.

The cost of wire will vary with the gauge and the insulation but for usual house work should cost, for No. 14 wire, 2 cents a foot.

It is well to remember that, in electric wiring, the larger the house, the more per outlet the wiring will cost. This seems contrary to expectation but is occasioned by the smaller percentage of lights to length of wire.

Bells. The number of call bells in a dwelling will vary according to the plan and choice of the owner.

For an ordinary house the number would range from six to ten, and the cost should be from $18.00 to $25.00 or about $3.00 per bell.



COUNTRY HOUSE AT BETHLEHEM, N. H.

H. V. von Holst, Architect, Chicago, Ill.

Walls of Shingles Stained a Silver Gray, Roofs of Shingles Stained a Deep Red Brown. The House is Located on Top of a Hill. Plans are shown on Page 298.

ESTIMATING

PART II

The taking-off of quantities and making-up of an actual estimate, is the end toward which our efforts are now directed. This is done, as has been said, in a number of ways, no two persons arriving at the same conclusion or following exactly the same methods. To give the student a practical idea of how estimates are made, we shall now demonstrate the method of procedure in an actual instance. For this purpose, we shall take the case of the wooden Colonial residence of which the plans and working drawings, and the method of making these, are fully described in the course on "Architectural Drawing," and of which the details are also described to a certain extent in the chapters on "Building Superintendence;" and shall proceed at once to take off the quantities and make up an estimate of cost.

Method. The usual method followed is to take off the quantities in the order in which they occur in the specification or in the operation of building, beginning with the Excavation and ending with the Painting.

Two methods of procedure are open to the Contractor, which he may avail himself of according to his experience or confidence. He may take off simply his own particular branch of the work, relying on each sub-contractor to give him a price for the detailed portions of the work; or, if he is a general contractor, he may, with the requisite knowledge of general building operations, take off all the quantities, pricing them according to his knowledge, and may submit his proposition on the basis of his own figures. The latter method requires great experience, and is followed generally by large contractors, who have in their employ men whose business is mainly to take off quantities and make up estimates.

The following estimate has been carefully made up on the basis of the data given in Part I as to prices of materials and labor. In actual practice, details of more or less importance will vary in different localities and among different contractors; but the example here given illustrates the process fully.

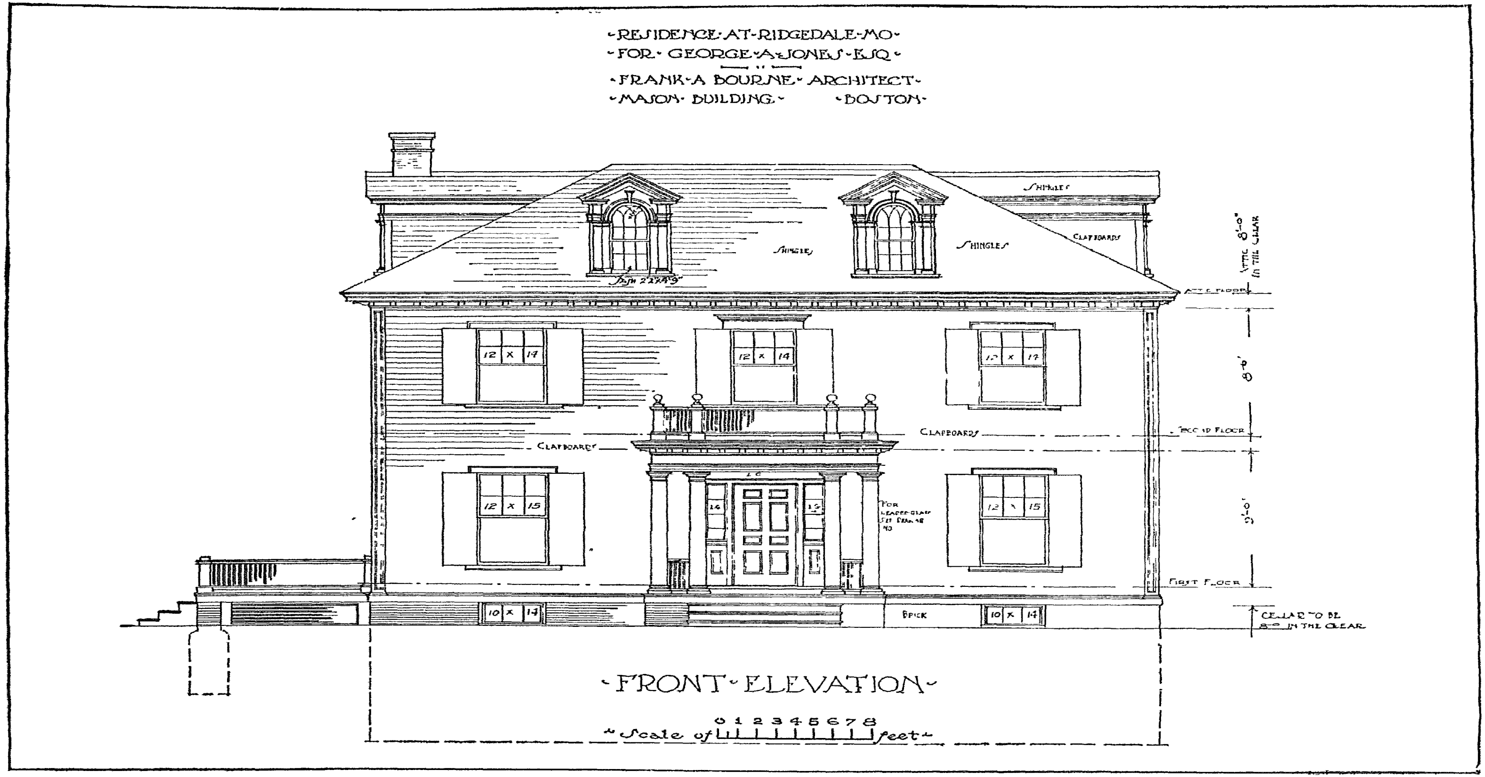

·RESIDENCE·AT·RIDGEDALE·MO·
·FOR·GEORGE·A·JONES·ESQ·
·FRANK·A BOURNE·ARCHITECT·
·MASON·BUILDING·
·BOSTON·
SHINGLES
SHINGLES
SHINGLES
CLAPBOARDS
Sash 22x49"
ATTIC 8'-0" IN THE CLEAR
ATTIC FLOOR
8'-6'
SECOND FLOOR
9'-0'
FIRST FLOOR
CELLAR TO BE 8'-0" IN THE CLEAR
12 x 17
12 x 14
12 x 17
CLAPBOARDS
CLAPBOARDS
12 x 15
14
15
FOR LEADED GLASS SEE DRAW'G NO
12 x 15
10 x 14
BRICK
10 x 14
·FRONT·ELEVATION·
0 1 2 3 4 5 6 7 8
Scale of feet

Fig. 1.

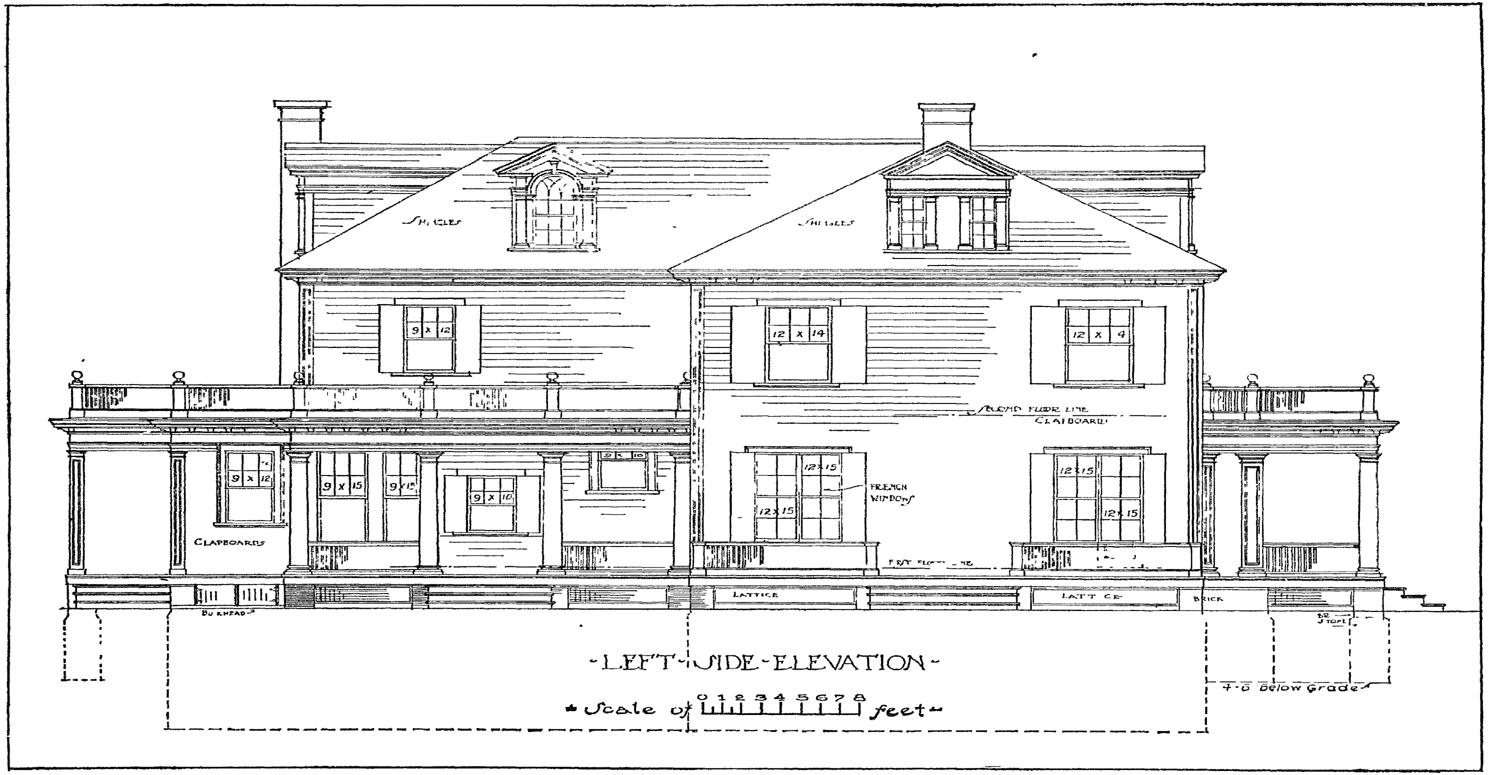

SHINGLES
SHINGLES
9 x 12
12 x 14
12 x 4
SECOND FLOOR LINE
CLAPBOARD
9 x 12
9 x 15
9 x 15
9 x 10
9 x 10
12 x 15
12 x 15
FRENCH WINDOWS
12 x 15
12 x 15
CLAPBOARDS
FIRST FLOOR LINE
LATTICE
LATTICE
BRICK
BULKHEAD
12 STONE
4'-0 Below Grade
-LEFT-SIDE-ELEVATION-
Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 2

ESTIMATE

OF

RESIDENCE AT RIDGEDALE, MO.

FOR GEORGE A. JONES, ESQ.

Staking-out and setting batter-boards	$15.00
Water supply during construction	10 00
	$25.00

EXCAVATION

Note.—Excavation is priced by the cubic yard; and in this regard, the distance to which the excavated material must be carted will be an important consideration. In the present case, the material is to be carried only a short distance, so that no unusual conditions will have to be considered.

As before mentioned, it is usually well to dig a cellar at least a foot larger all around than the sill line, so that plenty of room may be afforded to the mason to plaster the outside of the wall. This should be done without regard to the specifications. As this extra excavation lies entirely outside the line of the house, it may be well to take it off separately, remembering that it will extend down into the trench below the wall, making about 8 feet of height.

Quantities—	Cu. Ft.
42 ft. 0 in. × 8 ft. 0 in. × 1 ft. 0 in.	336
34 ft. 0 in. × 8 ft. 0 in. × 1 ft. 0 in.	272
10 ft. 4 in. × 8 ft. 0 in. × 1 ft. 0 in.	83
17 ft. 6 in. × 8 ft. 0 in. × 1 ft. 0 in.	140
68 ft. 0 in. × 8 ft. 0 in. × 1 ft. 0 in.	544
41 ft. 0 in. × 8 ft. 0 in. × 1 ft. 0 in.	328
Cellar Excavations—	
28 ft. 0 in. × 43 ft. 0 in. × 5 ft. 6 in.	6,622
12 ft. 6 in. × 3 ft. 0 in. × 5 ft. 6 in.	206
26 ft. 0 in. × 20 ft. 6 in. × 5 ft. 6 in.	2,931
9 ft. 0 in. × 6 ft. 6 in. × 5 ft. 6 in.	322
Carried forward	11,784 cu. ft.

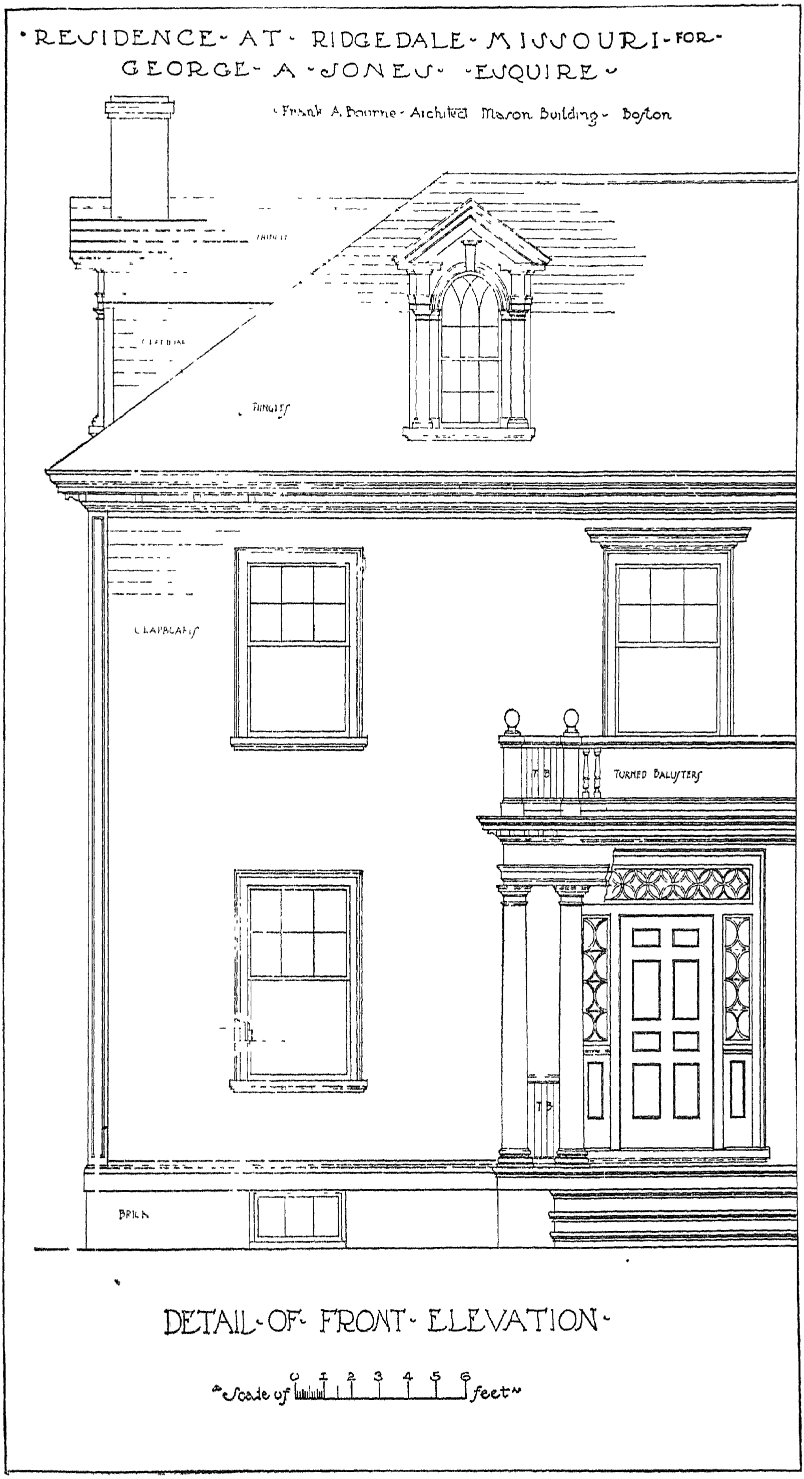

RESIDENCE AT RIDGEDALE MISSOURI FOR
GEORGE A JONES ESQUIRE
Frank A. Bourne Architect Mason Building Boston
SHINGLES
CLAPBOARDS
SHINGLES
CLAPBOARDS
TB
TURNED BALUSTERS
TB
BRICK
DETAIL OF FRONT ELEVATION
Scale of 0 1 2 3 4 5 6 feet

Fig. 3

Brought forward 11,784 cu. ft.

MISCELLANEOUS QUANTITIES—

Piers

2 ft. 0 in. × 2 ft. 0 in. × 3 ft. 6 in. × 12 168

Trench

185 ft 0 in. × 1 ft. 8 in. × 1 ft. 0 in....... 308

Area

14 ft. 0 in. × 2 ft. 8 in. × 3 ft. 6 in. 129

Drains

123 ft. 0 in. × 3 ft. 6 in. × 1 ft. 6 in. 645

Cesspools

5 ft. 6 in. × 5 ft. 6 in. × 8 ft. 0 in. .. . 242
10 ft. 0 in. × 10 ft. 0 in. × 8 ft. 0 in. 800

Dry Wells

6 × 2 ft. 0 in. × 2 ft. 0 in. × 5 ft. 0 in. 120

Total, 14,196 cu. ft.

Total, 14,196 cu. ft., or 525 cu. yds., at 50 cents . . $262 50

STONEWORK

DRY WALLS IN TRENCH— CU. FT.

16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in....... 27
16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. 27
12 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in. 20.8
3 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. ... 5
23 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. 38
16 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in 27.5
28 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. 46
28 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. . .. 46
14 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in. 24
4 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in... .... 7.5
23 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. 38

Total, 306.8 cu. ft.

307 cu. ft. ÷ 25 = 12 perches of dry wall.

MORTAR WALLS—

16 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in. 175
16 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in. 175
9 ft. 6 in. × 8 ft. 3 in. × 1 ft. 8 in. 130

Carried forward 480 cu. ft.

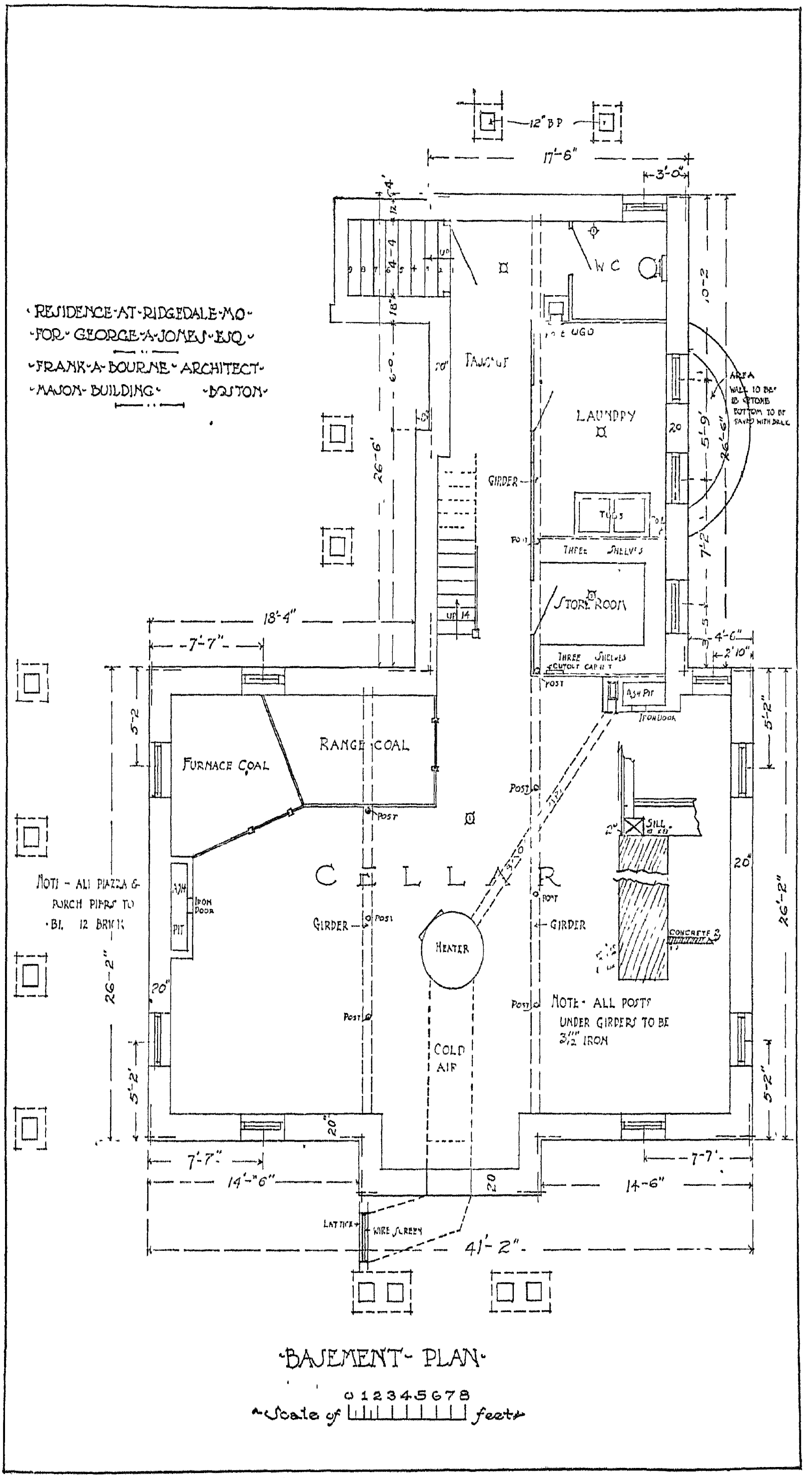

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
12" B P
17'-6"
3'-0"
W C
LAUNDRY
TUBS
THREE SHELVES
STORE ROOM
THREE SHELVES
GIRDER
POST
ASH PIT
IRON DOOR
AREA
WALL TO BE 12 STONE
BOTTOM TO BE PAVED WITH BRICK
10'-2
5'-9'
26'-6"
7'-2
4'-6"
2'10"
26'-6'
6'-0
18'-4"
7'-7"
5'-2
UP 14
FURNACE COAL
RANGE COAL
CELLAR
HEATER
COLD AIR
ASH PIT
IRON DOOR
GIRDER
POST
SILL
CONCRETE
20"
26'-2"
5'-2"
NOTE - ALL PIAZZA & PORCH PIERS TO BE 12 BRICK
NOTE - ALL POSTS UNDER GIRDERS TO BE 3½" IRON
7'-7"
14'-6"
20
41'-2"
LATTICE
WIRE SCREEN
BASEMENT PLAN
0 1 2 3 4 5 6 7 8
Scale of feet

Fig. 4.

	Brought forward	480 cu. ft.
	23 ft. 0 in. × 8 ft. 3 in. × 1 ft. 8 in.	316
	12 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in.	132
	28 ft. 0 in. × 8 ft. 3 in. × 1 ft. 8 in.	385
	6 ft. 0 in. × 6 ft. 7 in. × 1 ft. 6 in.	59
	10 ft. 0 in. × 6 ft. 7 in. × 1 ft 0 in.	66
	8 ft. 6 in. × 6 ft. 7 in. × 1 ft. 8 in.	93
	9 ft. 0 in. × 8 ft. 3 in. × 1 ft. 8 in	123
	25 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in	274
	6 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in.	66
	23 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in.	252
PIERS—		
	2 ft. 6 in. × 5 ft. 6 in. × 1 ft. 0 in.	14
	2 ft. 6 in. × 5 ft. 6 in. × 1 ft. 0 in.	14
	2 ft. 0 in. × 2 ft. 0 in. × 1 ft. 0 in.	4
	12 ft. 0 in. × 3 ft. 6 in. × 2 ft. 0 in.	84
	12 ft. 0 in. × 3 ft. 6 in. × 2 ft. 0 in.	84
AREA—		
	14 ft. 0 in. × 3 ft. 6 in. × 1 ft. 6 in.	73
	Total,	2,519 cu. ft.

2,519 cu. ft ÷ 25 = 101 perches of mortar wall.

UNDERPINNING—		CU. FT.
	16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	45
	16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	45
	6 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	17
	12 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	34
	6 ft. 0 in. × 1 ft. 0 in. × 1 ft. 0 in.	6
	8 ft. 6 in. × 1 ft. 8 in. × 1 ft. 8 in.	23
	25 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	70
	6 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	17
	23 ft. 0 in. × 1 ft. 8 in. × 1 ft. 8 in.	64
	14 ft. 0 in. × 2 ft. 0 in. × 1 ft. 6 in.	42
	Total,	363 cu. ft.

363 cu. ft. ÷ 25 = 14½ perches of underpinning.

Summary of Stonework—

12 perches of dry wall, at $3.00	$ 36.00
Carried forward	$ 36.00

Brought forward	$ 36.00
101 perches of mortar walls, at $4.25	429.25
14½ perches of underpinning, at $6 50	94 25
Total cost of Stonework,	$559.50

PLASTERING WALLS WITH CEMENT

192 ft. 0 in. × 6 ft. 7 in. = 1,264 sq. ft. = 140 sq. yds., at $.40 $ 56.00

CESSPOOLS

Leaching Cesspool—		
23 ft. 6 in. × 8 ft. 0 in. × 1 ft. 6 in. = 282 cu. ft. ÷ 25 = 11⅓ perches.		
11⅓ perches at $3.50	$39.65	
Cover	2.50	42.15
Tight Cesspool—		
11 ft. 6 in. × 8 ft. 0 in. = 92 sq. ft. × 15 bricks = 1,380 bricks.		
1,380 bricks at $20.00 per M.	$27.60	
Iron cover	3 00	30.60

DRY WELLS

2 ft. 0 in. × 2 ft. 0 in. × 5 ft. 6 in. × 12 = 264 cu. ft. ÷ 25 = 11 perches	
11 perches at $2.50	27.50

DRAINS

171 ft. at $.20	$34.20	
14 bends at $.30	4 20	38.40
Total cost of Stonework, Cesspools, and Drains		$754.15

BRICKWORK

Note.—Find the number of bricks in a foot of height in each chimney or pier, reckoning five courses to the foot of height.

Cellar—

35 × 8	280
107½ × 8	860
55 × 8	440
Carried forward	1,580 bricks

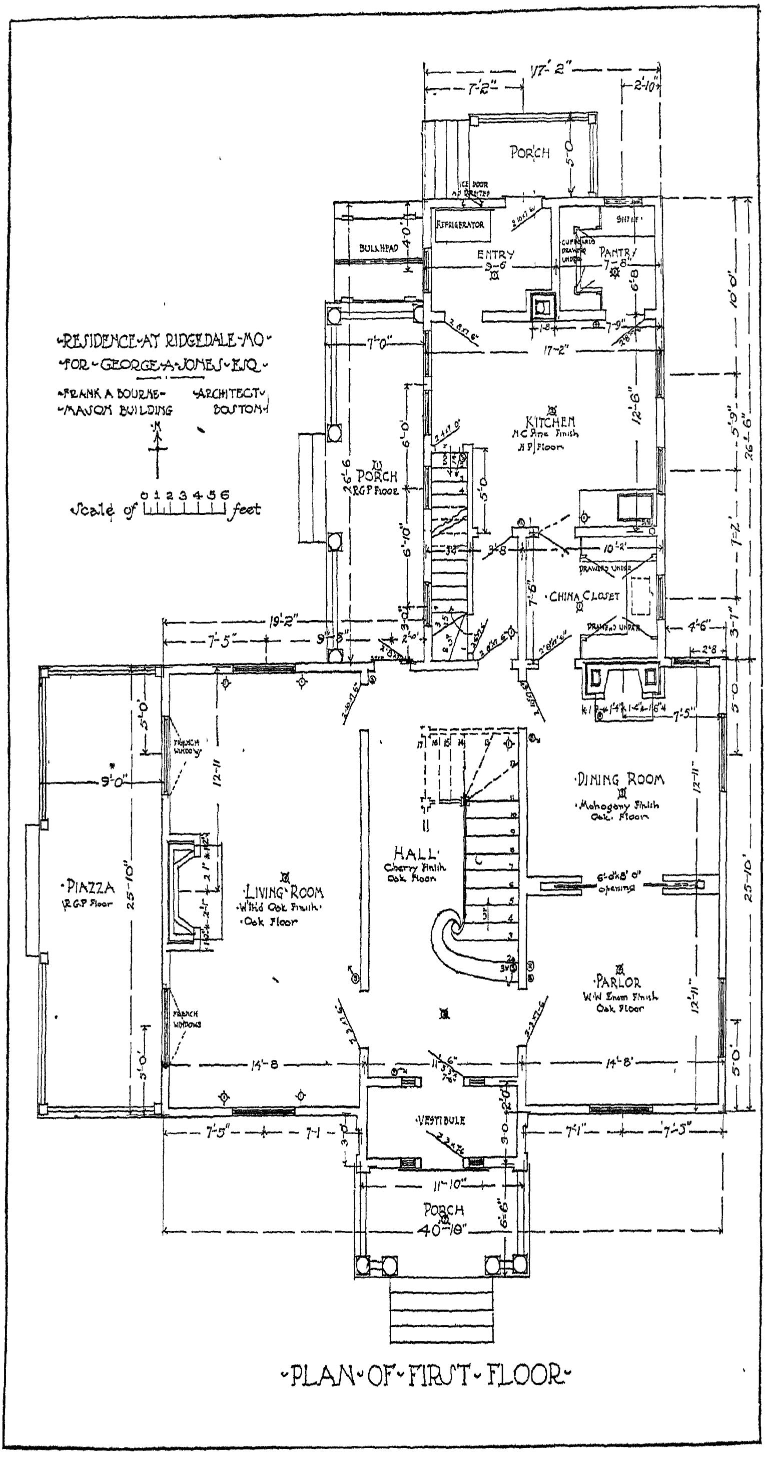
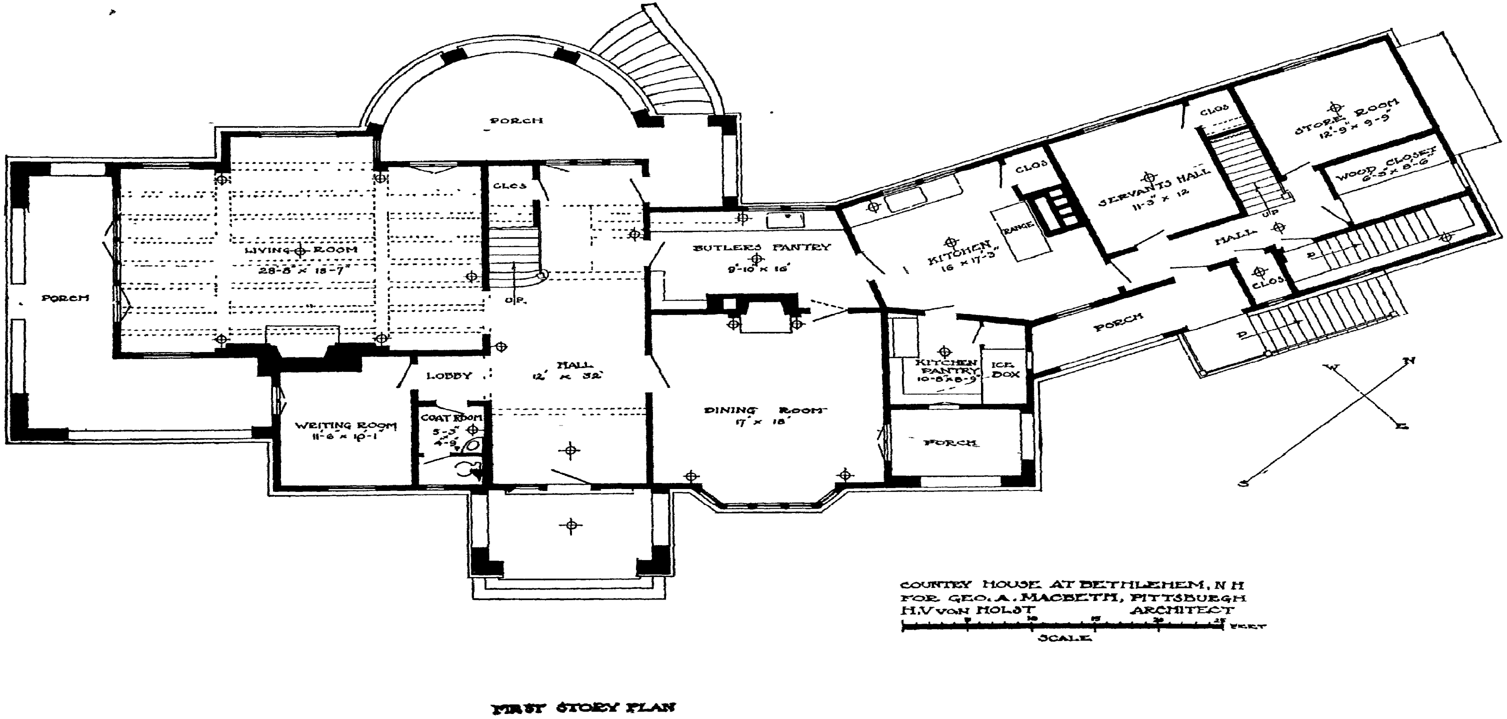
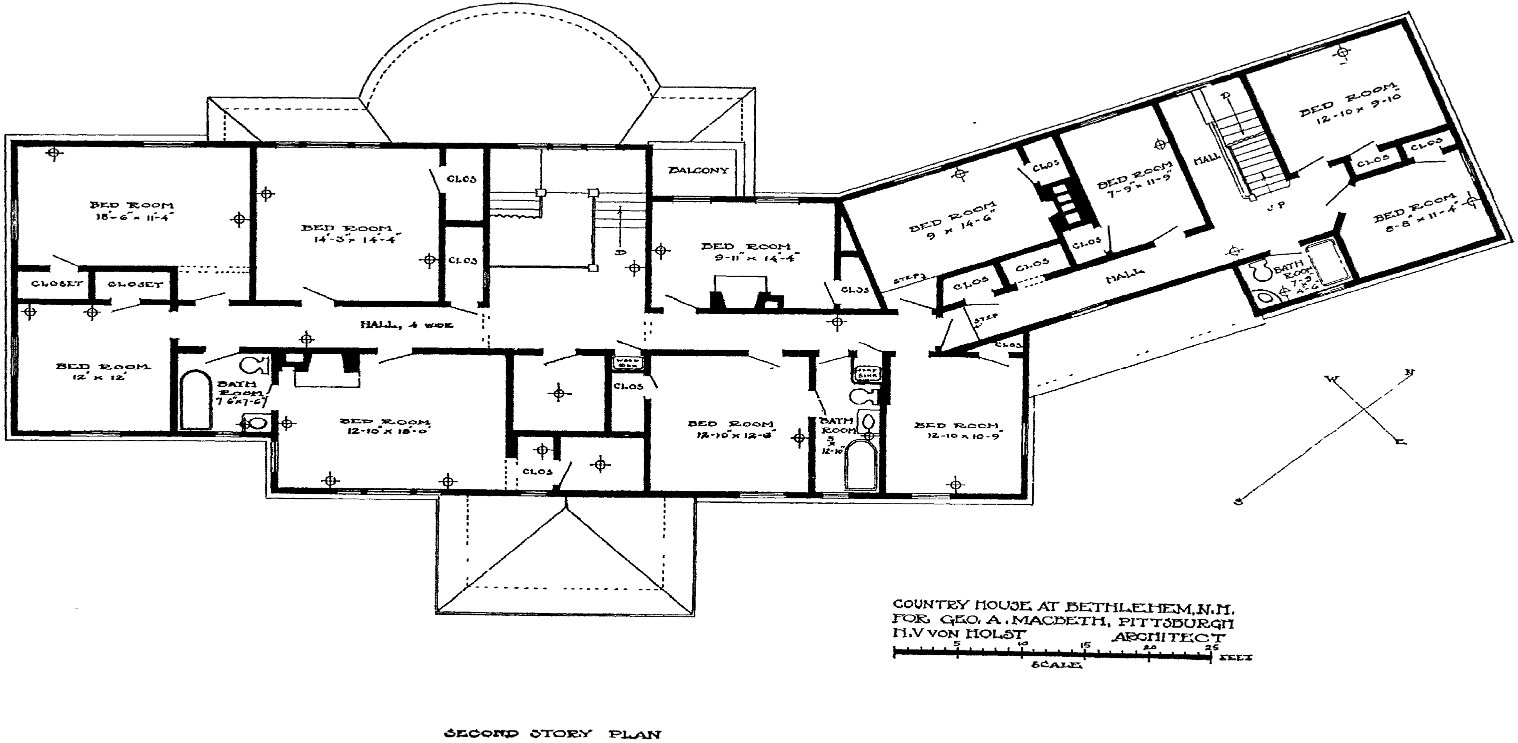

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
N
Scale of 0 1 2 3 4 5 6 feet
PORCH
ICE DOOR AND SHELVES
REFRIGERATOR
BULKHEAD
ENTRY 9-6
CUPBOARDS DRAWERS UNDER
PANTRY 7-8
SHELF
KITCHEN
H C Pine Finish
H P Floor
PORCH
R G P Floor
CHINA CLOSET
DRAWERS UNDER
DRAWERS UNDER
FRENCH WINDOWS
FRENCH WINDOWS
PIAZZA
R G P Floor
LIVING ROOM
W'th'd Oak Finish
Oak Floor
HALL
Cherry Finish
Oak Floor
DINING ROOM
Mohogany Finish
Oak Floor
6'-0"x8'-0" opening
PARLOR
W.W Enam Finish
Oak Floor
VESTIBULE
PORCH
17'-2"
7'-2"
2'-10"
17'-2"
10'-0"
12'-6"
5'-9"
26'-6"
7'-2"
3'-1"
4'-6"
2'-8"
7'-0"
26'-6"
6'-0"
6'-10"
3'-0"
19'-2"
7'-5"
9'-8"
5'-0"
9'-0"
25'-10"
5'-0"
12'-11"
14'-8
14'-8"
12'-11"
12'-11"
25'-10"
5'-0"
5'-0"
7'-5"
7'-1
7'-1"
7'-5"
11'-10"
40'-10"
6'-6"
PLAN OF FIRST FLOOR

Fig. 5.



FIRST-STORY PLAN OF COUNTRY HOUSE AT BETHLEHEM, N. H.

The Living Room Affords a View into the Littleton Valley, to the Northwest The View from the Dining Room is toward Mount Washington. The South Porch Looks Out on Mount Lafayette. Living Room Finished in Oak, Natural, Dining Room, Stair Hall, and Writing Room, in Cypress; Bedrooms in White Pine; Servants' Rooms in Georgia Pine. House Built in 1904-05. Cost, $11,000. For Exterior, See Page 288.



SECOND-STORY PLAN OF COUNTRY HOUSE AT BETHLEHEM, N. H.
First-Story Plan Shown on Opposite Page.

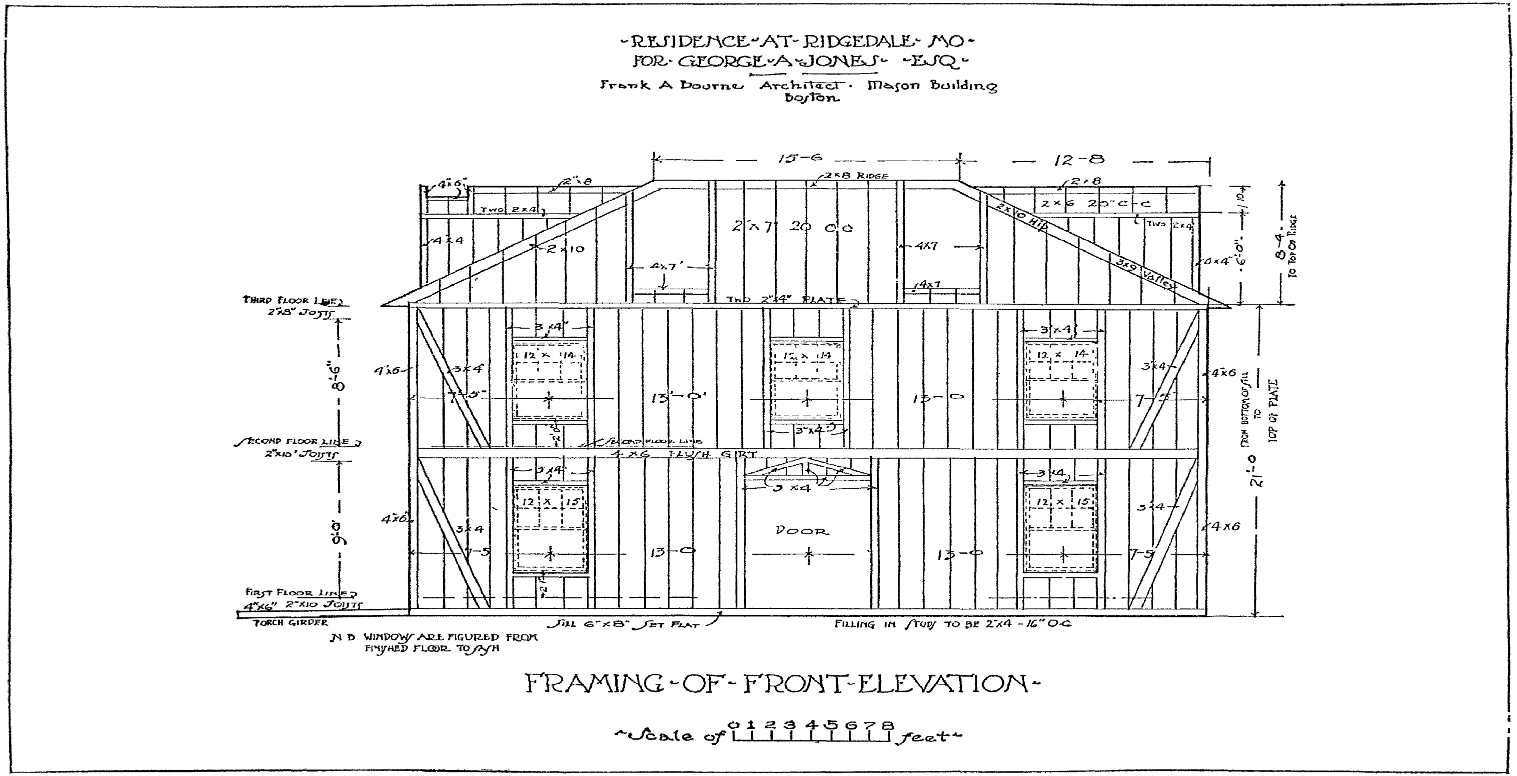
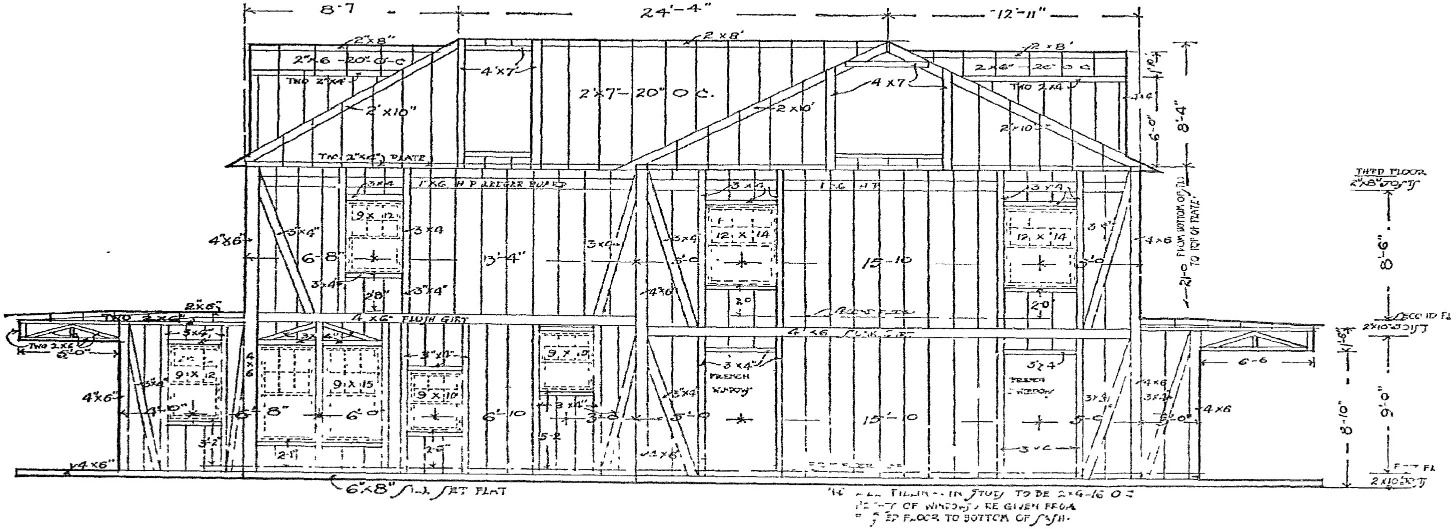

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
Frank A Bourne Architect Mason Building Boston
15-6
12-8
2×8 RIDGE
2"×8
2×8
4×6"
Two 2×4
4×4
2×10
2×7 20 O C
4×7'
4×7
4×7
2×6 20" C-C
Two 2×4
2×10 Hip
3×9 Valley
4×4"
10
6'-0"
8-4
TO TOP OF RIDGE
THIRD FLOOR LINE
2"×8" JOISTS
TWO 2"×4" PLATE
3×4"
3×4
12×14
12×14
12×14
3"×4
4×6
3×4
7'-5"
13'-0'
13-0
7'-5"
8'-6"
SECOND FLOOR LINE
2"×10' JOISTS
SECOND FLOOR LINE
4×6 FLUSH GIRT
3×4
12×15
12×15
3×4
DOOR
4×6
7-5
13-0
13-0
7-5
9'-0"
21'-0
FROM BOTTOM OF SILL TO TOP OF PLATE
FIRST FLOOR LINE
4"×6" 2"×10 JOISTS
PORCH GIRDER
SILL 6"×8" SET FLAT
FILLING IN STUDS TO BE 2×4 - 16" O.C.
N B WINDOWS ARE FIGURED FROM FINISHED FLOOR TO SASH
FRAMING OF FRONT ELEVATION
Scale of 0 1 2 3 4 5 6 7 8 feet

Fig 6.



'FRAMING·OF·LEFT·SIDE·ELEVATION·

~Scale of 0 1 2 3 4 5 6 7 8 9 feet~

Fig. 7

	Brought forward	1,580 bricks
VERANDA PIERS—		
	58½ × 10	585
CHIMNEYS—		
	107½ × 6 ft. 6 in.	700
	105 × 11 ft. 0 in.	1,155
	35 × 11 ft. 0 in.	385
	35 × 4 ft 6 in.	157
	127½ × 5 ft. 6 in.	701
	35 × 19 ft. 0 in.	665
	57½ × 4 ft. 0 in.	230
	127½ × 11 ft. 0 in.	1,402
		7,560 bricks

Summary—

7,560 bricks at $20.00 per M., laid	$ 151.20
3 fireplaces at $30.00 each	90 00
FLUE LININGS—	
26 ft., 13 in. × 13 in., at $.35	9 10
36 ft., 9 in. round, at $.30	10 80
68 ft., 8½ × 13, at $.30	20 40
Total cost of Brickwork and Flue Linings,	$ 281.50

CONCRETING

	SQ. FT.
23 ft. 0 in. × 38 ft. 0 in.	874
3 ft. 0 in. × 9 ft. 6 in.	28½
15 ft. 0 in. × 26 ft. 0 in.	390
4 ft. 0 in. × 7 ft. 0 in.	28
	1,320 sq. ft.

Total, 1,320 sq. ft. = 147 sq. yds., at $.60 . . . . $88.20

PLASTERING

NOTE.—Take off square feet of plastered surfaces, and deduct one-half of the openings, after reducing to sq. yds.

CELLAR—		SQ. FT.
	23 ft. 0 in. × 38 ft 0 in.	874
	9 ft. 6 in. × 3 ft. 0 in.	28
	Carried forward	902 sq. ft.

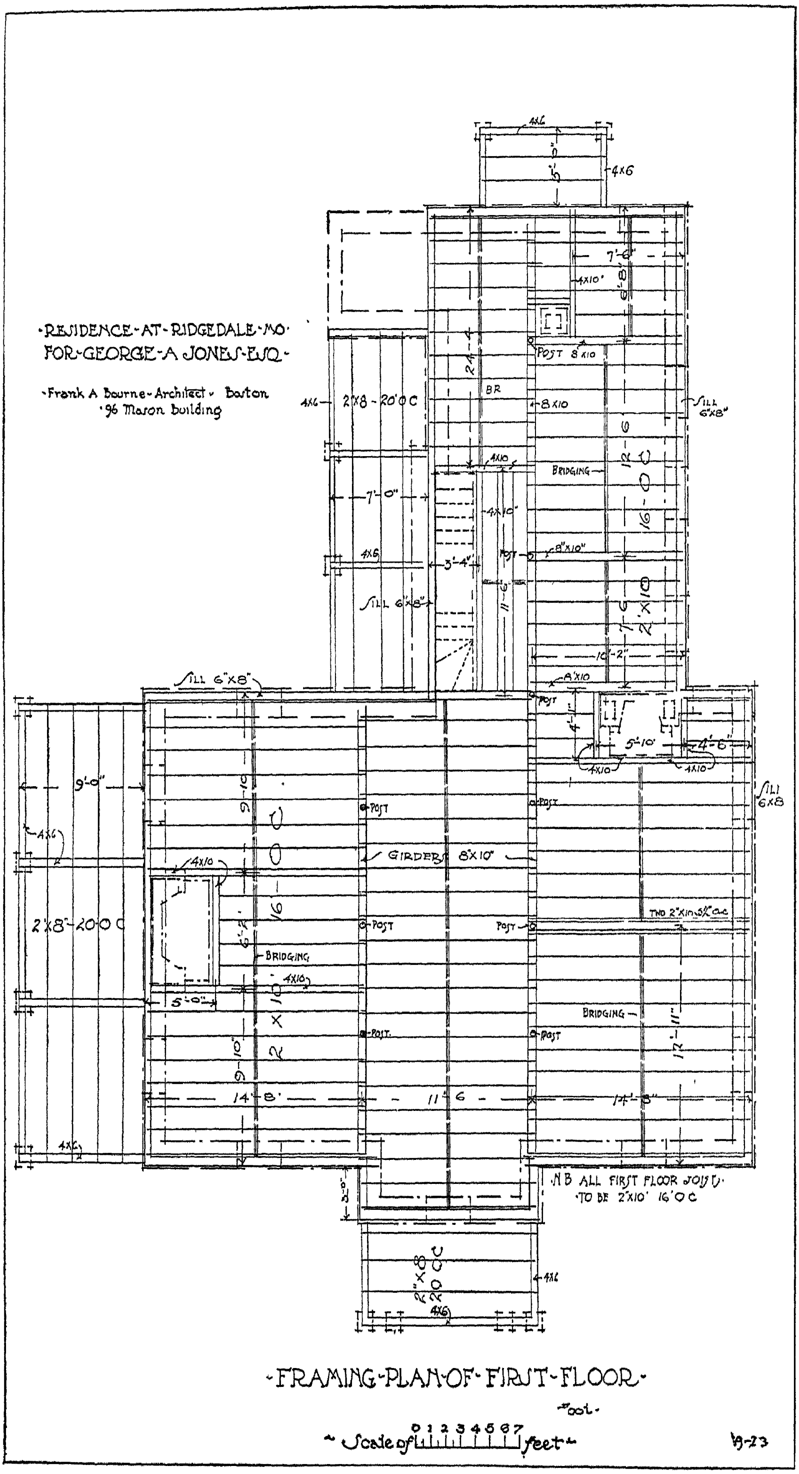

·RESIDENCE·AT·RIDGEDALE·MO·
FOR·GEORGE·A·JONES·ESQ·
·Frank A Bourne·Architect· Boston
·96 Mason Building
4x6
5'-0"
7'-6"
6'-8"
4x10'
POST 8x10
24'-4"
BR
8x10
SILL 6"x8"
4x6
2"x8-20"O C
BRIDGING
12'-0"
16"-O C
7'-0"
4x10
4x10"
4x6
3'-4"
POST
8"x10"
11'-6"
2"x10
7'-6"
SILL 6"x8"
10'-2"
8'x10
SILL 6"x8"
POST
4'-1"
5'-10'
4'-6"
4x10
4x10
SILL 6x8
9'-0"
4x6
9'-10"
16"-O C
POST
GIRDERS 8"x10"
POST
4x10
2"x8"-20"O C
6'-2"
POST
POST
TWO 2"x10 16"O C
BRIDGING
4x10
5'-0"
2" x 10'
POST
POST
BRIDGING
12'-11"
9'-10"
14'-8"
11'-6
14'-8"
4x6
3'-0"
N B ALL FIRST FLOOR JOISTS
TO BE 2"x10' 16"O C
2"x8 20"O C
4x6
4x6
·FRAMING·PLAN·OF·FIRST·FLOOR·
Scale of 0 1 2 3 4 5 6 7 feet
19-23

Fig. 8.

Brought forward	902 sq. ft.
15 ft. 6 in. × 26 ft. 0 in.	403
30 ft. 0 in. × 8 ft. 0 in.	240
	1,545 sq. ft.

First Story—

25 ft. 0 in. × 40 ft. 0 in.	1,000
11 ft. 0 in. × 3 ft. 0 in.	33
25 ft. 6 in. × 16 ft. 6 in.	420
490 ft. 0 in. × 9 ft. 0 in.	4,410
	5,863 sq. ft.

Second Story—

	Sq. Ft.
25 ft. 0 in. × 40 ft. 0 in.	1,000
16 ft. 6 in. × 19 ft. 0 in.	313
520 ft. 0 in. × 8 ft. 6 in.	4,420
	5,733 sq. ft.

Total amount of plastered surfaces, 13,141 sq. ft.

Outs—

32 doors, average 40 sq. ft.	1,280
34 windows, average 15 sq ft.	510
	1,790 sq. ft.

1,790 sq. ft. ÷ 2 = 895 sq. ft.

13,141 sq. ft. less 895 sq. ft. = 12,246 sq. ft. = 1,361 sq. yds.

Total cost of Plastering 1,361 sq. yds., at $.40 . . . . $ 544.40

CARPENTER WORK

Frame—

				Ft. B. M.
188 linear ft.,	6 ×	6 in.	sill	564
136 " "	4 ×	6 in.	"	272
74 " "	8 ×	10 in.	girders	494
250 " "	4 ×	6 in.	posts	500
188 " "	4 ×	6 in.	girts	376
				2,206

2,206 ft. B. M. at $38.00 per M. . . . . $ 83.82

First-Story Frame, Bridging and Under Floor—

25 ft. 0 in. × 40 ft. 0 in.	1,000	
Carried forward		$ 83.82

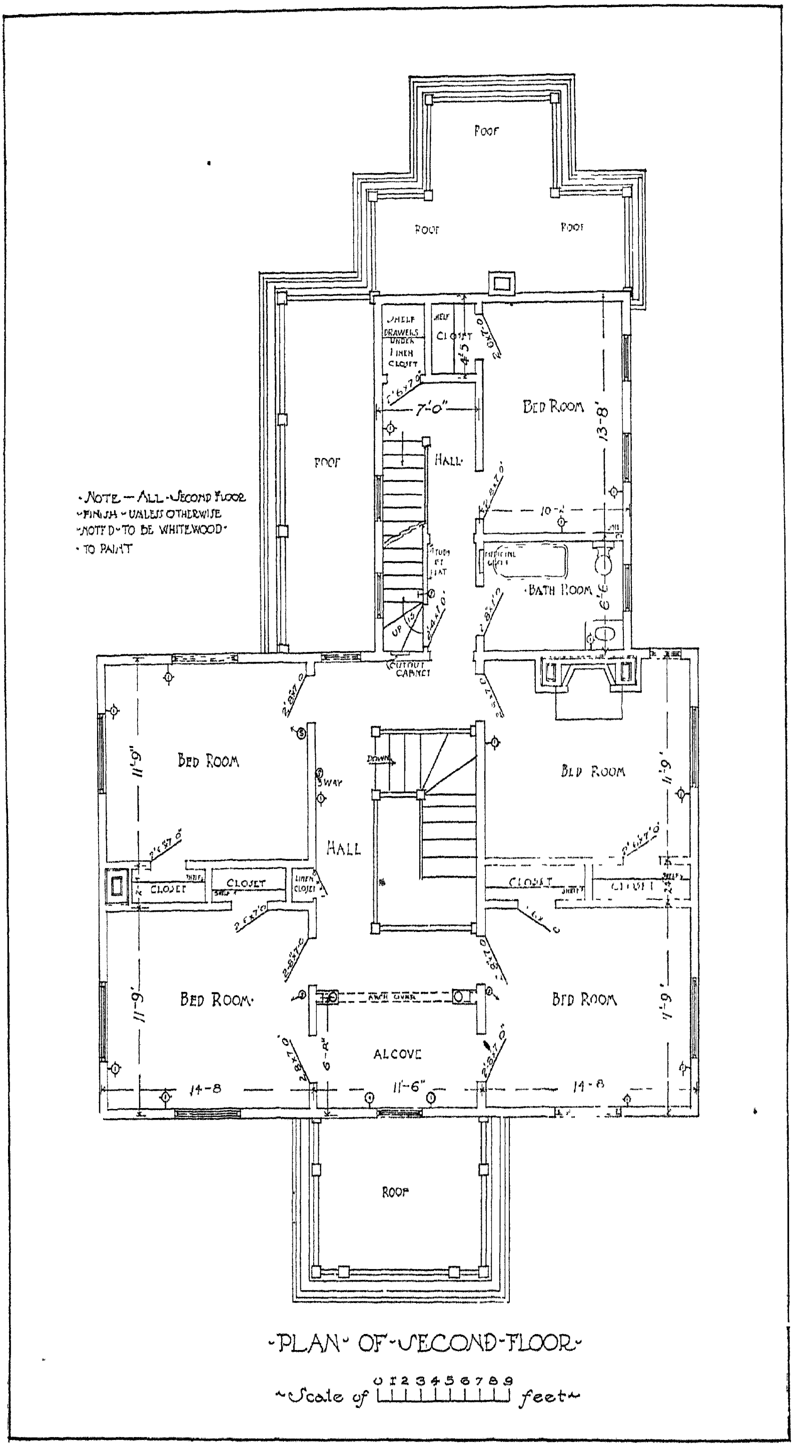

ROOF
ROOF
ROOF
SHELF
DRAWERS UNDER
LINEN CLOSET
SHELF
CLOSET
4'-5"
2'6"x7'0"
2'6"x7'0"
7'-0"
BED ROOM
13'-8"
ROOF
HALL
NOTE — ALL SECOND FLOOR FINISH UNLESS OTHERWISE NOTED TO BE WHITEWOOD TO PAINT
10'-4"
MEDICINE CLOSET
BATH ROOM
6'-6"
UP 15
CUTOUT CABINET
BED ROOM
11'-9"
2'8"x7'0"
3 WAY
DOWN
HALL
BED ROOM
11'-9"
2'6"x7'0"
CLOSET
CLOSET
LINEN CLOSET
SHELF
CLOSET
CLOSET
2'6"x7'0"
2'8"x7'0"
BED ROOM
11'-9"
ARCH OVER
BED ROOM
11'-9"
ALCOVE
6'-8"
2'8"x7'0"
14-8
11'-6"
14-8
ROOF
PLAN OF SECOND FLOOR
Scale of 0 1 2 3 4 5 6 7 8 9 feet

Fig. 9.

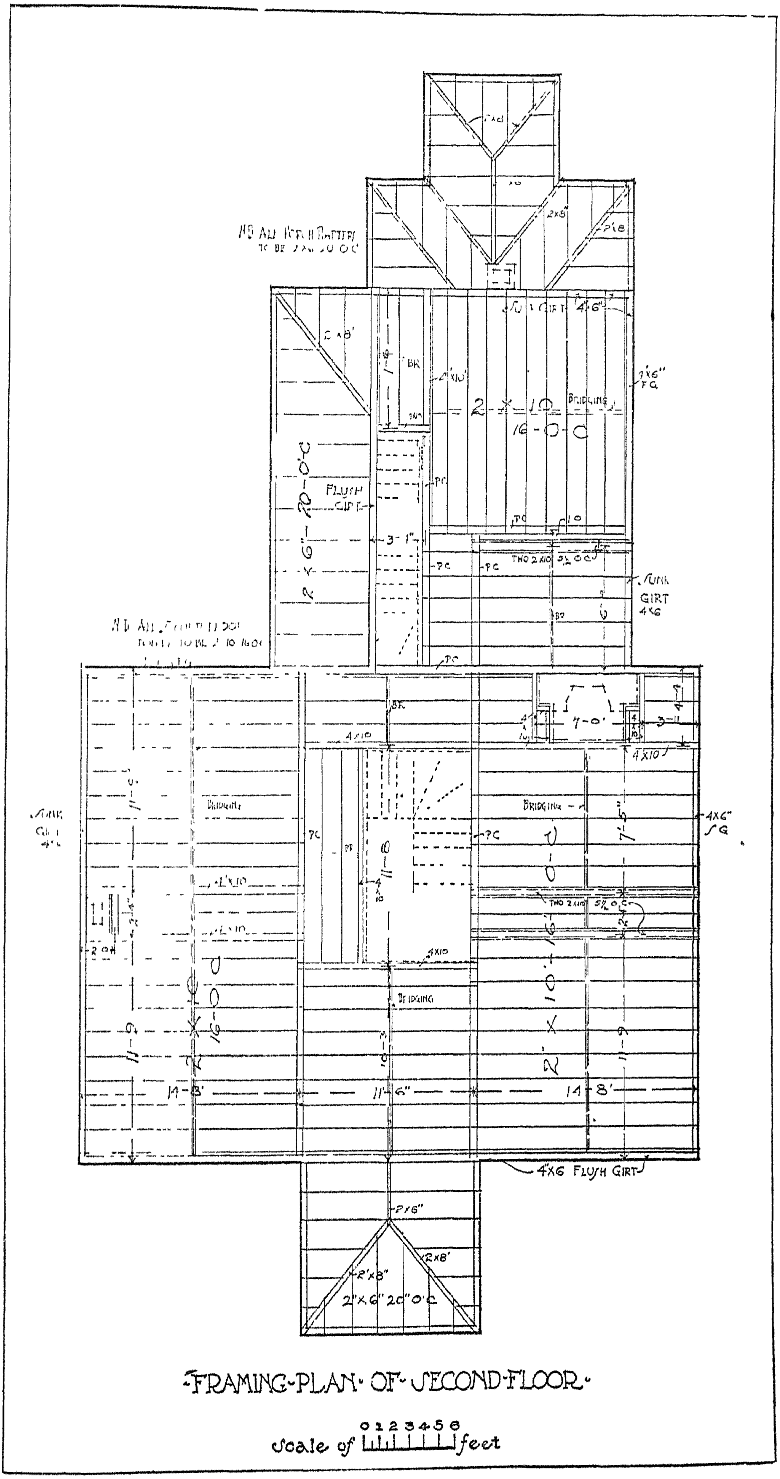

N.B. All Porch Rafters to be 2x6 20 O.C.
2x8
2x8
2x8
2x8'
Sunk Girt 4x6"
2x6" F.G.
BR
4x10
2 x 10
16-0-C
Bridging
2 x 6" 20-0-C
Flush Girt
PC
3-1"
PC
PC
Two 2x10 5½ O.C.
Sunk Girt 4x6
BR
6'
N.B. All Floor Joists to be 2x10 16 O.C.
PC
BR
4x10
7-0'
3-11
4-4
4x10
Sunk Girt 4x6
Bridging
4x6" S.G.
PC
PC
11-8
4x10
2x10
2x10
Two 2x10 5½ O.C.
7'-5"
2 x 10-16-0-C
2 x 10 16-0-C
11-0
11-9
4x10
Bridging
10-3
11-9
14-8'
11-6"
14-8'
4x6 Flush Girt
2x6"
2x8'
2'x8"
2"x6" 20" O.C.
·FRAMING·PLAN·OF·SECOND·FLOOR·
0 1 2 3 4 5 6
Scale of feet

Fig. 10.

Brought forward $ 83 82
11 ft. 0 in. × 3 ft. 0 in. 33
26 ft. 0 in. × 16 ft. 6 in. 429
1,462 sq. ft.
1,462 sq. ft. = 14.62 squares, at $9.35 per square . . . . . . $ 136.70

UPPER FLOOR—
Hard Pine
25 ft. 6 in. × 16 ft. 6 in. = 421 sq. ft., at $10.50 per square . . . . $ 44.21
Oak
25 ft. 0 in. × 40 ft. 0 in. = 1,000 sq. ft.
11 ft. 0 in. × 3 ft. 0 in. = 33 "
1,033 sq. ft.
1,033 sq. ft. at $20.00 per square. . . . . $ 206.60

PORCH FLOOR—
6 ft. 0 in. × 11 ft. 0 in. = 66 sq. ft.
9 ft. 0 in. × 5 ft. 0 in. = 45 "

PIAZZA FLOOR—
26 ft. 0 in. × 9 ft. 0 in. = 234 "
20 ft. 6 in. × 7 ft. 0 in. = 144 "
489 sq. ft.
489 sq. ft. at $12.35 per square . . . . . $ 60.39

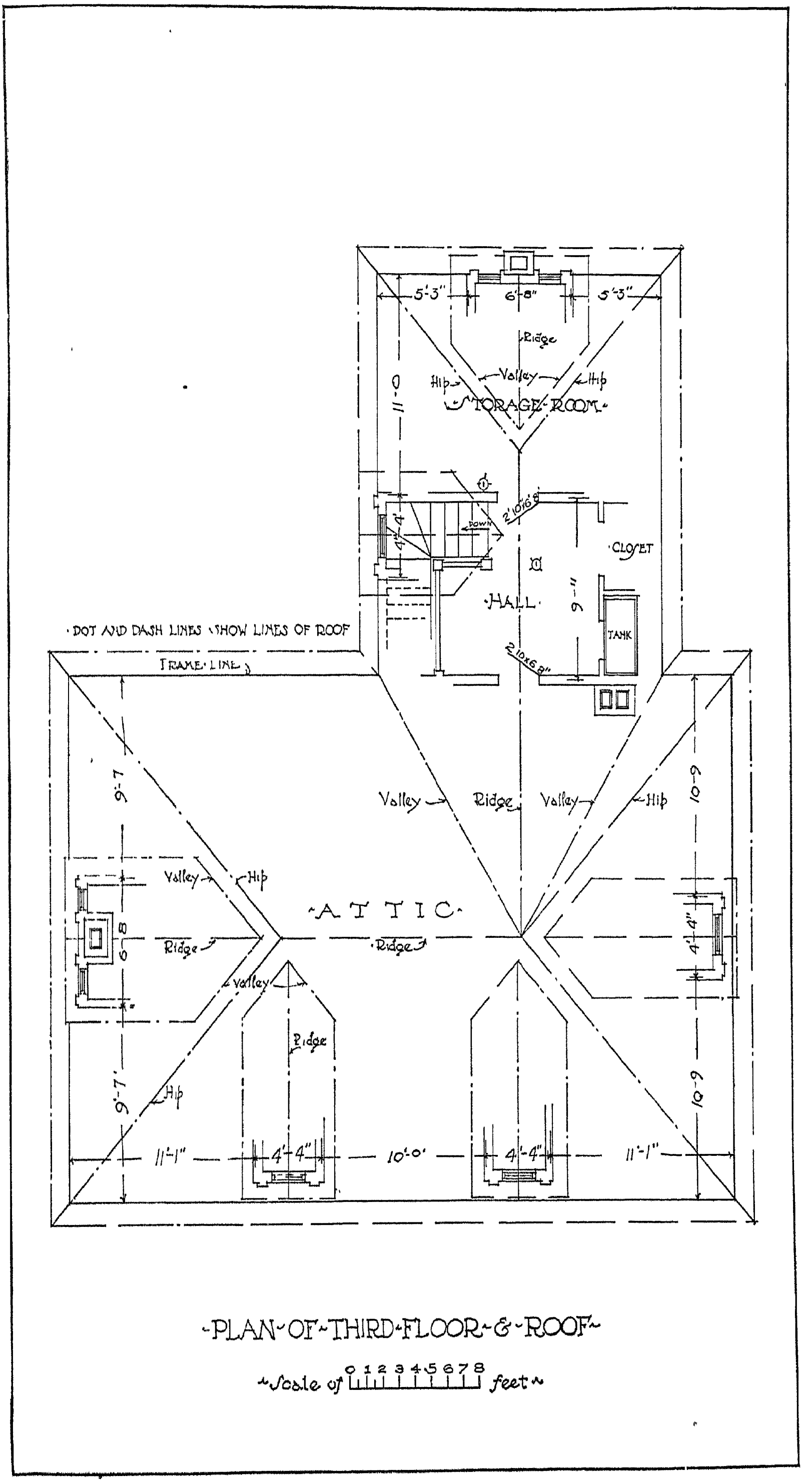
SECOND-STORY FRAME, BRIDGING AND STRAPPING FLOORS—
40 ft. 0 in. × 25 ft. 0 in. . . . . 1,000 sq. ft.
20 ft. 0 in. × 17 ft. 0 in. . . . . 340 " "
1,340 sq. ft.
1,340 sq. ft. at $18.00 per square . . . . . . $ 241.20

THIRD STORY—
1,340 sq. ft. at $10.10 per square . . . . $ 135.34

ROOF FRAME, BOARDING AND SHINGLES—
30 ft. 0 in. × 16 ft. 6 in. × 2 sides. . 990 sq. ft.
34 ft. 0 in. × 16 ft. 6 in. × 2 sides. . 1,122 " "
2,112 sq. ft.
2,112 sq. ft. at $16.67 per square. . . . . $ 352.07

FLASHING . . . . $ 40.00

TIN ROOF, FRAME AND BOARDING—
21 ft. 0 in. × 7 ft. 6 in. . . . . 157 sq. ft.
Carried forward $1,300.33



PLAN OF THIRD FLOOR & ROOF

Scale of feet

Fig. 11.

Brought forward			$1,300.33
19 ft. 0 in. × 6 ft. 6 in.	124 sq. ft.		
11 ft. 0 in. × 5 ft. 6 in.	60 " "		
14 ft. 0 in. × 9 ft. 6 in.	133 " "		
	474 sq. ft.		
474 sq. ft. at $20.92 per square			$ 99.16

OUTSIDE WALLS, STUDDING AND BOARDING—

172 ft. 0 in. × 20 ft 0 in.	3,440 sq. ft.		
6 ft. 6 in. × 10 ft. 0 in. × 2 sides	130 " "		
3 ft. 0 in. × 9 ft. 0 in. × 2 sides	54 " "		
	3,624 sq. ft.		
3,624 sq. ft. at $8.30 per square			$ 300.79

INSIDE STUDDING—

180 ft. 0 in. × 9 ft. 0 in.	1,620 sq. ft.		
196 ft. 0 in. × 8 ft. 6 in.	1,666 " "		
28 ft. 0 in. × 8 ft. 0 in.	224 " "		
	3,510 sq. ft.		
3,510 sq. ft., at $4.00 per square			$ 140.40

CLAPBOARDING—

44 ft. 0 in. × 19 ft. 0 in. × 2 sides.	1,672 sq. ft.		
6 ft. 0 in. × 8 ft. 0 in. × 2 sides.	96 " "		
2 ft. 0 in. × 9 ft. 0 in. × 2 sides.	36 " "		
39 ft. 0 in. × 19 ft. 0 in. × 2 sides.	1,482 " "		
	3,286 sq. ft.		
3,286 sq. ft. at $7.95 per square . . .		$261.23	
Deduct for stock only, 36 windows = 546 sq. ft., at $4.70 per square		25.38	$ 235.85

MISCELLANEOUS

DORMERS—

6, at $50 each.			$ 300.00

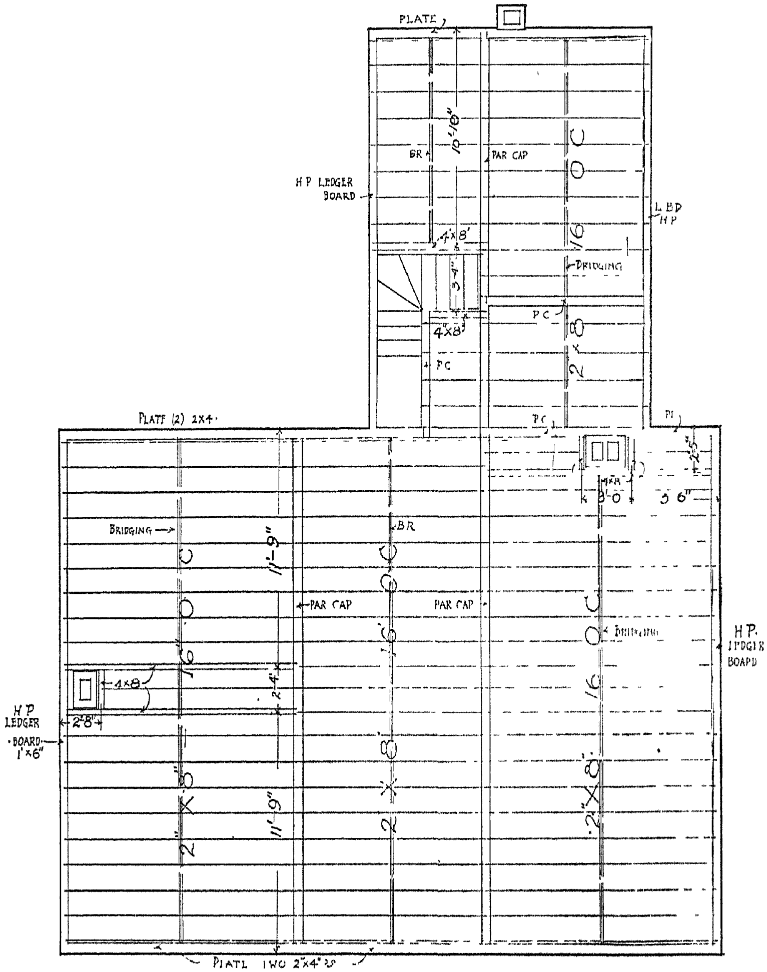
MAIN CORNICE—

180 ft., at $1.25 per ft.			225.00

BALUSTRADE ON ROOF—

96 ft., at $0.50 per ft.		$48.00	
18 posts, at $1.50 each		27.00	75.00
Carried forward			$2,676.53

PIAZZA FINISH—	*Brought forward*	$2,676.53
Cornice—		
102 ft., at $2.00 per ft.		204 00
Columns—		
9 in place, at $10.00 each		90 00
Corner Pilasters—		
2½ in place, at $8.00 each		20.00
Balustrade—		
76 ft., at $.50 per ft.	$38.00	
Small Posts—		
8½, at $1.00 each	12 00	50.00
Outside Steps		25.00
Lattice—		
55 ft. 0 in. × 1 ft. 6 in. = 82½ sq. ft., at $.15 per sq. ft.		12.37
Porch Ceiling—		
111 sq. ft., at $10.00 per square		11.10
BULKHEAD STEPS		25.00
CORNER BOARDS—		
252 ft. 0 in. × 8 in. = 168 sq. ft., at $.30 per sq. ft.		50.40
WATER TABLE—		
117½ linear ft., at $.20 per ft.		23.50
WINDOWS AND FRAMES—		
Attic—		
4 windows, circular top, at	$11.20 each	$ 44.80
4 windows, square, at	$5.25 each	21.00
Second Story—		
8 windows, 3 ft. 6 in. × 5 ft. 0 in., at	$13.33 each	$106.64
7 windows, 2 ft. 6 in. × 4 ft. 6 in., at	$11.44 each	80.08
First Story—		
1 window, 2 ft. 6 in. × 4 ft. 6 in.		$ 11.44
2 windows, 2 ft. 6 in. × 5 ft. 6 in., at	$12.00 each	24.00
2 windows, 2 ft. 6 in. × 3 ft. 9 in., at	$11.00 each	22.00
2 pairs French windows (oak), 4 ft. 6 in. × 7 ft. 6 in., at	$18.24 each	36.48
1 window, 3 ft. 4 in. × 5 ft. 6 in. (oak finish)		16.57
	Carried forward	$3,550.91



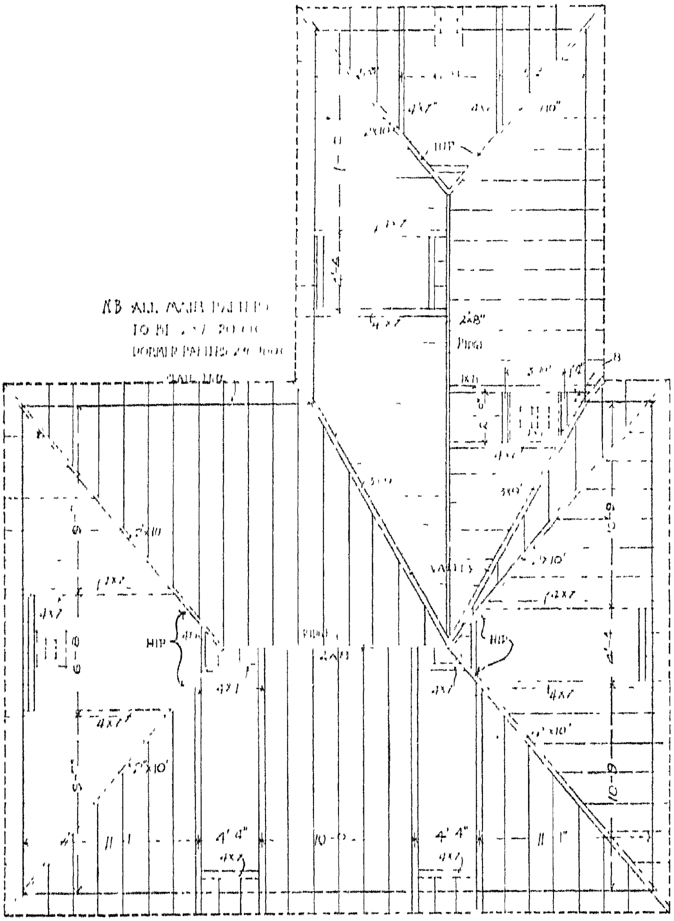
·FRAMING·PLAN·OF·THIRD·FLOOR·

Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 12.

Brought forward		$3,550.91
1 window, 3 ft. 4 in. × 5 ft. 6 in. (birch finish)		16.57
1 window, 2 ft. 6 in. × 5 ft. 6 in. (birch finish)		14.45
2 windows, 3 ft. 4 in. × 5 ft. 5 in. (whitewood), at $13.33 each		26.66
4 windows, 2 ft. 6 in. × 4 ft. 6 in. (N. C. pine), at $11.44 each		45.76
FRONT DOOR, with side and top lights—		
3 ft. 3 in. × 7 ft. 6 in.		56.33
REAR DOOR—		
2 ft. 10 in. × 7 ft. 6 in.		13.46
CELLAR SASHES—		
12, at $3.25 each		39.00
INSIDE FINISH—		
Coal bins in basement, 240 sq. ft.		
Studding 240 sq. ft. at $3 00 per square	$ 7.20	
Boarding 240 " " $4.75 " "	11.40	
Labor on 2 doors, one day	3.25	21.85
COLD-AIR BOX—		
3 ft. 0 in. × 1 ft. 0 in., 25 ft. long, at $.62 per linear ft.		15.50
BASEMENT PARTITIONS—		
46 ft. 0 in. × 8 ft. 0 in., 368 sq. ft., at $8.75 per square		32.20
3 doors, at $8.87 each		26.61
67½ ft. shelving, at $.15 per ft.		10.12
1 door to bulkhead		10.00
FIRST STORY—		
1 door, 2 ft. 8 in. × 7 ft. 6 in. (whitewood and birch finish)		20.67
1 pair sliding doors (whitewood and birch finish)		53.52
40 ft. birch base at $.20 per ft.		8.00
1 door, 3 ft. 3 in. × 7 ft. 6 in. (whitewood and oak)		22.67
1 door, 2 ft. 10 in. × 7 ft. 6 in. (whitewood and oak)		20.67
WOOD CORNICE IN DINING ROOM—		
56 ft., 6 in. × 6 in. (birch), at $.48 per ft.	$26 88	
56 ft. picture moulding, at $.06 per ft.	3.36	30.24
WOOD CORNICE IN LIBRARY—		
82 ft., 6 in. × 6 in. (oak), at $.48 per ft.	$39.36	
Carried forward	$39.36	$4,035.19

Brought forward	$39.36	$4,035.19
82 ft. picture moulding, at $.06 per ft.	4.92	44.28
OAK BASE—		
72 ft. at $.20 per ft.		14.40
1 door, 3 ft. 0 in. × 7 ft. 6 in (whitewood).		12.59
VESTIBULE DOOR, side lights and top light, same as front door.		56.33
WHITEWOOD BASE, 101 ft., at $.10 per ft.		10.10
5 doors (N. C. pine), at $9.48 each		47.40
CHINA CLOSET FINISH		100.00
PANTRY		50.00
KITCHEN AND BACK ENTRY SHEATHING—		
65 linear ft., at $.40 per ft.		26.00
MANTELS—		
Allowance	$125.00	
Labor of setting	6.50	$131.50
SECOND STORY—		
16 doors stock, at $9.48 each		$151.68
1 arch in hall		10.00
2 wood columns, at $10.00 each		20.00
5 closets, at $3.50 each		17.50
1 linen closet		25.00
1 linen closet		20.00
THIRD STORY—		
2 doors, finished one side, at $7.04 each		$ 14.08
1 closet door		7.04
Tank		10.00
Finished floor, 100 sq. ft.		7.25
Base, 14 ft., at $.10 per ft.		1.40
CONDUCTORS—		
120 ft., at $.13 per ft., put up	$15.60	
6 goosenecks, at $1.00 each	6.00	$ 21.60
CUTTING AND FITTING FOR PLUMBING AND HEATING		35.00
FREIGHT, FARES AND EXPENSES		50.00
INSURANCE		10.00
Total cost of Carpenter Work		$4,928.34



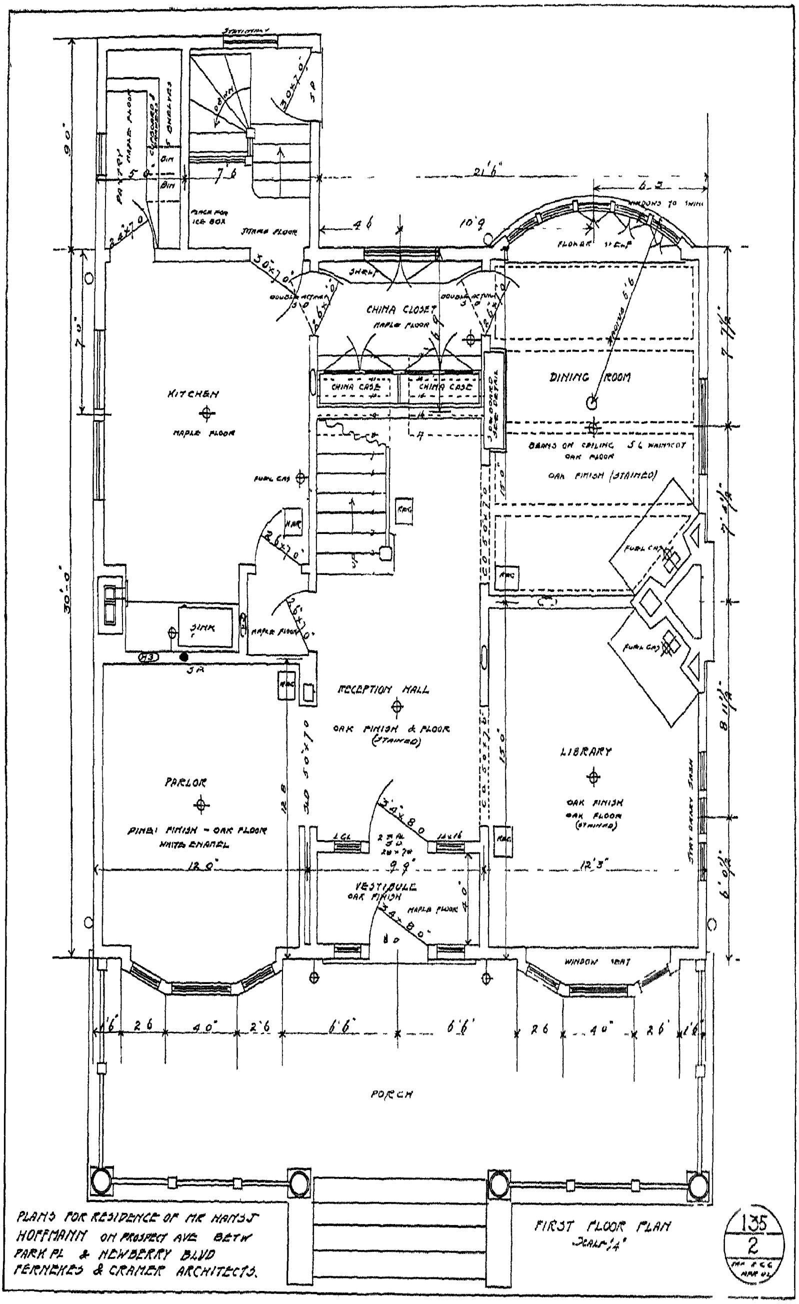
-FRAMING-PLAN-OF-ROOF-

-Scale of 0 1 2 3 4 5 6 7 8 *feet.-*

Fig. 15.

STAIRS

Front Stairs—		
128 ft. spruce, at $30 per M.	3.84	
120 ft. whitewood, at $70 per M.	8.40	
85 ft. quartered oak, at $150 per M.	12.75	
30 ft. mahogany rail and turn	24.00	
5 paneled posts at $5.00 each	25.00	
105 balusters at $.15 each	15.75	
11 nosings at $.06 each	.66	
25 scotias at $.03 each	.75	
Nails, glue, etc.	1.00	
Labor	56.00	$148.15
Back Stairs—		
First Flight—		
55 ft. spruce, at $30 per M.	$ 1.65	
105 ft. N. C. pine, at $60 per M	6.30	
16 scotias at $.03 each	.48	
Nails, etc.	.75	
Labor	16.00	25.18
Second Flight—		
54 ft. spruce, at $30 per M.	$ 1.62	
110 ft. N. C. pine, at $60 per M	6.60	
17 scotias at $.03 each	.51	
Nails, etc.	.75	
1 post	.75	
4 ft. rail, at $.12½ per ft.	.50	
12 balusters at $.06¼ each	.75	
Labor	17.00	28.48
Cellar Stairs—		
40 ft. spruce, at $30 per M.	$ 1.20	
75 ft. N. C. pine, at $60 per M.	4.50	
Post	.50	
Rail	1.20	
Labor	5.00	12.40
		$214.21
Framing		2.00
Total cost of Stairs		$216.21

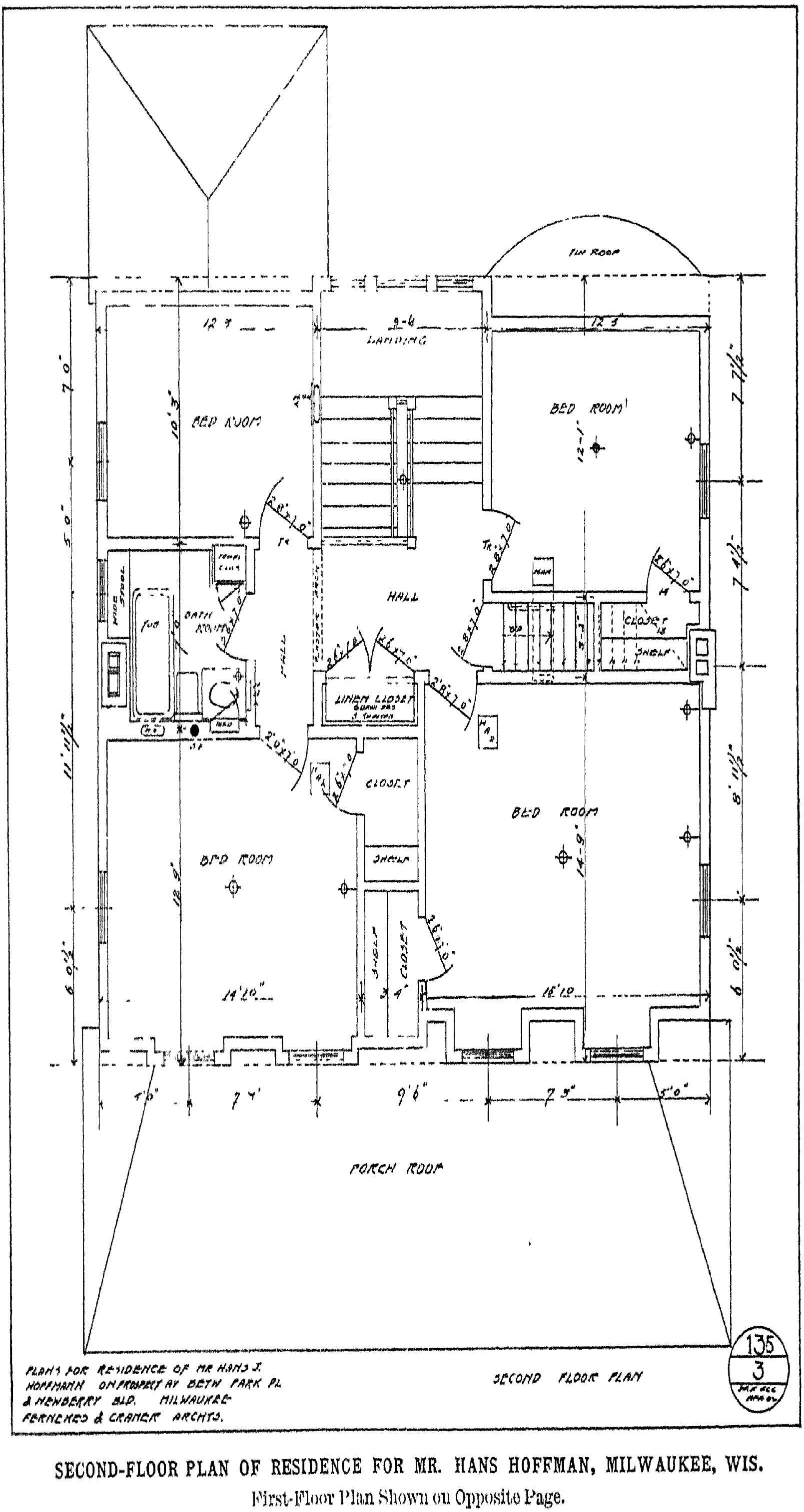


FIRST-FLOOR PLAN OF RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

COST OF HOUSE:

Mason Work	$ 625 00	Heating (Furnace)	$ 167 00
Carpentry	2,684 00	Painting	325 00
Tinning	36 00	Decorating	52 00
Plumbing	380 00		
Plastering	253 00	Total	$4,522 00

Built in 1902. Oak Wainscoting and Ceiling in Dining Room; Oak Finish in Stair Hall and All Main Rooms on First Floor; Cypress in Balance of House. For Exterior, See Page 331.



SECOND-FLOOR PLAN OF RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

First-Floor Plan Shown on Opposite Page.

HARDWARE

NOTE.—This estimate is based upon a fair quality of hardware, the butts being of bronze-plated steel, the knobs of struck-up bronze metal, with rose and escutcheon combined; the sash fasts of solid bronze metal, also lifts and catches.

BASEMENT

BULKHEAD, OUTSIDE—			
2 pairs extra heavy galv. T hinges, 8-inch at $.85 each		$1.70	
2 hooks and staples, 5-inch, at	$.10 each	.20	
Labor		1.00	
BULKHEAD, INSIDE—			
1 pair heavy T hinges, 8-inch		.15	
1 thumb-latch		.10	
Labor		.50	
THREE DOORS—			
3 pairs butts, 3½ × 3½-inch, at	$.15 each	.45	
3 sets locks at	$.45 each	1.35	
Labor		1.50	
HINGED WINDOWS—			
12 pairs butts, 1¼-inch, at	$.06 each	.72	
12 hooks and eyes, at	$.02 each	.24	
12 buttons, at	$.02 each	.24	
Labor		1.50	$ 9.65

FIRST FLOOR

ENTRANCE DOOR—			
1½ pairs butts, 4½ × 4½-inch, at	$.38 each	$ .57	
1 set locks, bronze metal		9.50	
Labor		2.00	
SEVEN INSIDE DOORS, FRONT—			
7 pairs butts, 3½ × 3½-inch, at	$.30 each	2.10	
7 sets locks at	$1 00 each	7.00	
Labor		5.25	
Carried forward		$26.42	$9.65

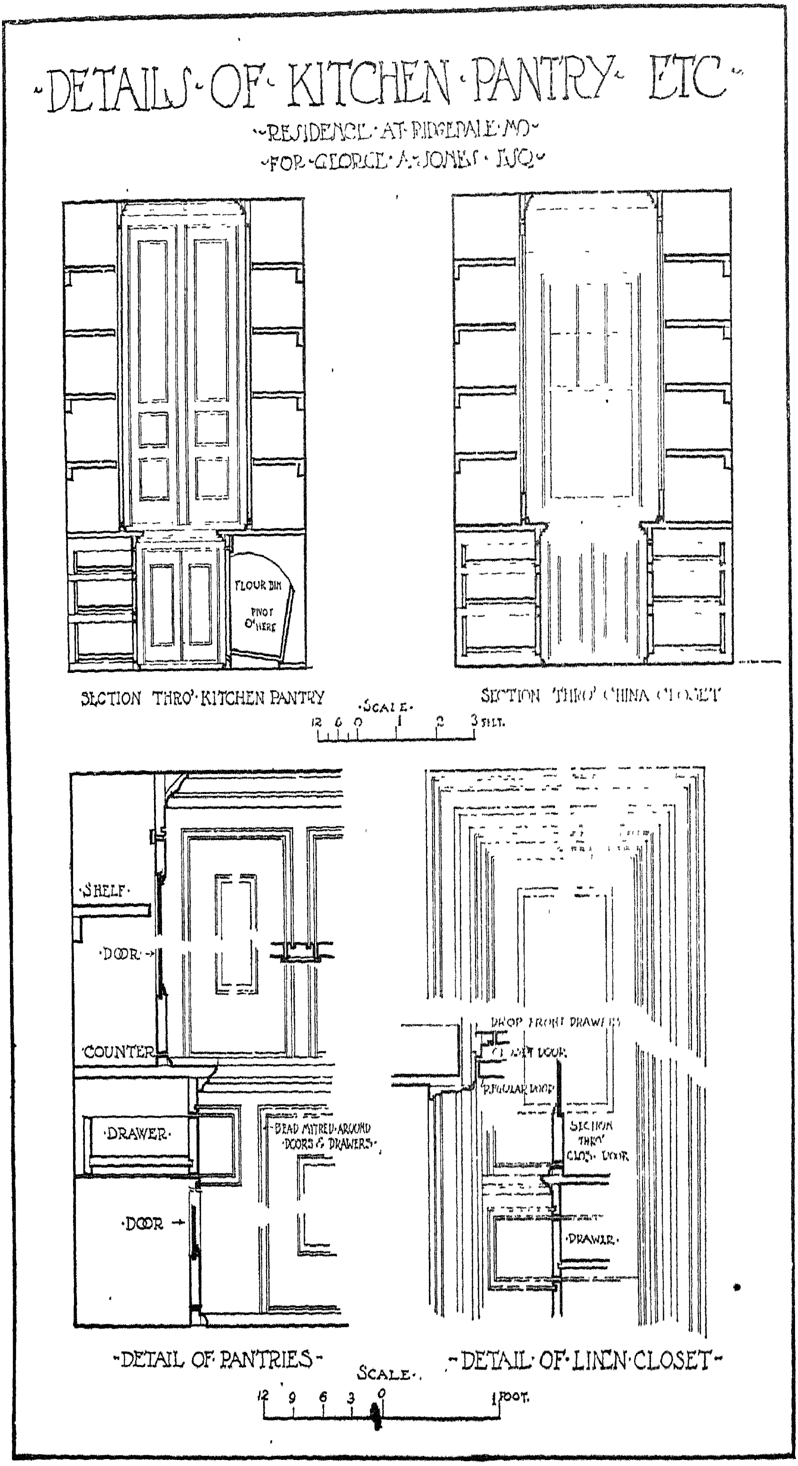
DETAILS OF KITCHEN PANTRY ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A. JONES ESQ
FLOUR BIN
PIVOT O' HERE
SECTION THRO' KITCHEN PANTRY
SCALE
12 6 0 1 2 3 FEET.
SECTION THRO' CHINA CLOSET
SHELF
DOOR
COUNTER
DRAWER
DOOR
BEAD MITRED AROUND DOORS & DRAWERS
DROP FRONT DRAWERS
CLOSET DOOR
REGULAR DOOR
SECTION THRO' CLOS. DOOR
DRAWER
DETAIL OF PANTRIES
SCALE
12 9 6 3 0 1 FOOT.
DETAIL OF LINEN CLOSET

Fig. 14.

Brought forward		$26.42	$9.65
SIDE ENTRANCE DOOR—			
1½ pairs butts, 4½ × 4½-inch, at	$.38 each	.57	
1 set locks		2.25	
Labor		1.00	
ONE PAIR SLIDING DOORS, 5 ft. 0 in.			
1 set hangers, 5 ft. 0 in, Double		3.50	
1 set S. D. locks		2.50	
Labor		2.00	
SIX INSIDE BACK PORTIONS—			
6 sets locks, at	$.45 each	2.70	
6 pairs butts, 3½ × 3½-inch, at	$.15 each	.90	
Labor		4.00	
BACK DOORS—			
1½ pairs butts, 4½ × 4½-inch, at	$.20 each	.30	
1 set locks		2.25	
Labor		1.00	
ICE-CHEST DOOR—			
1 pair butts, 3 × 3-inch		.40	
1 HI lever, galvanized		.60	
1 brass hasp and padlock		1.50	
Labor		.50	
CHINA CLOSET—			
2 pairs glass doors—			
2 pairs butts, 2½ × 2½-inch, at	$.26 each	.52	
2 elbow catches, at	$.06 each	.12	
2 cupboard catches, at	$.15 each	.30	
1 pair cupboard doors—			
2 pairs butts, 2½ × 2½-inch, at	$.10 each	.20	
1 elbow catch		.06	
1 cupboard catch		.15	
20 drawer-pulls, at	$.06 each	1.20	
Labor		2.50	
PANTRY—			
4 cupboard doors—			
4 pairs butts, 2½ × 2½-inch, at	$.10 each	.40	
Carried forward		$57.84	$9.65

	Brought forward	$57.84	$9.65
4 cupboard catches, at	$.15 each	.60	
1 bbl. swing		.75	
10 drawer-pulls, at	$.06 each	.60	
Labor		2.00	
WINDOWS—			
15 sash fasts, at	$.30 each	4.50	
30 sash lifts, at	$.06 each	1.80	
Labor		7.50	
CASEMENT WINDOWS,			
4 pairs butts, 3 × 3-inch, at	$.50 each	2.00	
2 pairs flush bolts, at	$1.00 each	2.00	
2 casement fasts, at	$.45 each	.90	
Labor		1.00	$81.49

SECOND FLOOR

SIXTEEN DOORS—			
16 pairs butts, 3½ × 3½-inch, at	$.30 each	$ 4.80	
16 sets locks, at	$.90 each	14.40	
Labor		10.40	
WINDOWS—			
14 sash fasts, at	$.30 each	4.20	
1 sash fast		.35	
28 sash lifts, at	$.06 each	1.68	
2 sash lifts, at	$.10 each	.20	
Labor		7.00	
SIX DRAWERS IN LINEN CLOSET—			
12 drawer-pulls, at	$.06 each	.72	
Labor		.25	$44.00
BATHROOM—			
1 pair butts, 3½ × 3½-inch (nickel-plate)		.40	
1 set locks (nickel-plate)		1.25	
Labor		.75	$ 2.40

ATTIC

TWO DOORS—			
2 pairs butts, 3½ × 3½-inch, at	$.12 each	$.24	
2 sets locks, at	$.45 each	.90	
Labor		1.00	
	Carried forward	$2.14	$137.54

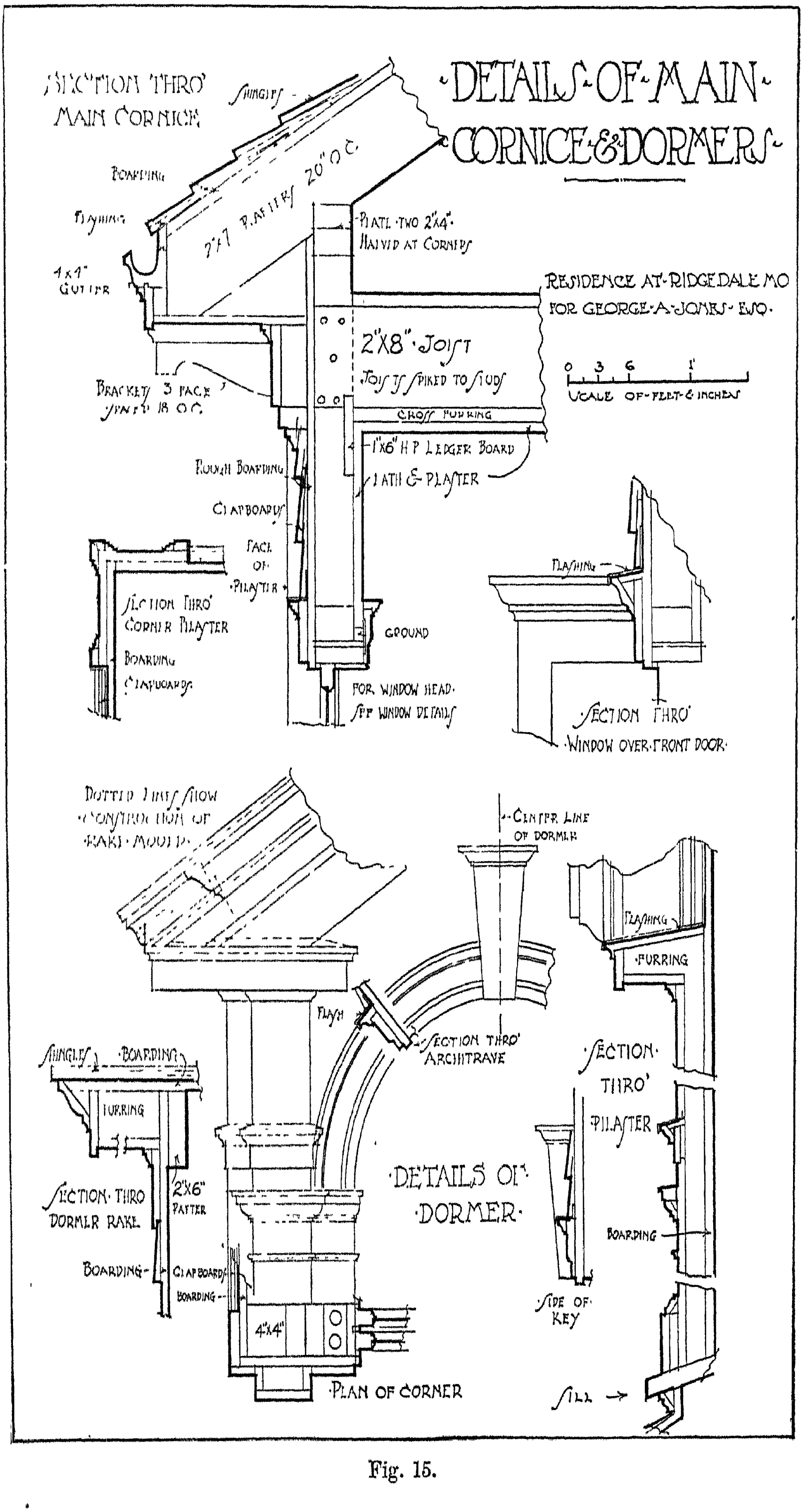

·DETAILS·OF·MAIN·
CORNICE·&·DORMERS·
SECTION THRO' MAIN CORNICE
SHINGLES
BOARDING
FLASHING
4x4" GUTTER
2"x7" RAFTERS 20" O.C.
PLATE·TWO 2"x4"· HALVED AT CORNERS
2"X8"·JOIST
JOISTS SPIKED TO STUDS
CROSS FURRING
1"X6" H P LEDGER BOARD
LATH & PLASTER
BRACKETS 3 FACE SPACED 18 O.C.
ROUGH BOARDING
CLAPBOARDS
FACE OF ·PILASTER
GROUND
FOR WINDOW HEAD· SEE WINDOW DETAILS
SECTION THRO' CORNER PILASTER
BOARDING
CLAPBOARDS
RESIDENCE AT·RIDGEDALE·MO FOR GEORGE·A·JONES·ESQ·
0 3 6 1'
SCALE OF·FEET·& INCHES
FLASHING
SECTION THRO' ·WINDOW OVER·FRONT DOOR·
DOTTED LINES SHOW ·CONSTRUCTION OF ·RAKE·MOULD·
CENTER LINE OF DORMER
FLASH
SECTION THRO' ARCHITRAVE
FLASHING
·FURRING
·SECTION· THRO' ·PILASTER
SHINGLES
·BOARDING
FURRING
SECTION·THRO DORMER RAKE
2"X6" RAFTER
BOARDING
CLAPBOARDS
BOARDING
4"x4"
·DETAILS OF· ·DORMER·
SIDE OF KEY
BOARDING
·PLAN OF CORNER
SILL

Fig. 15.

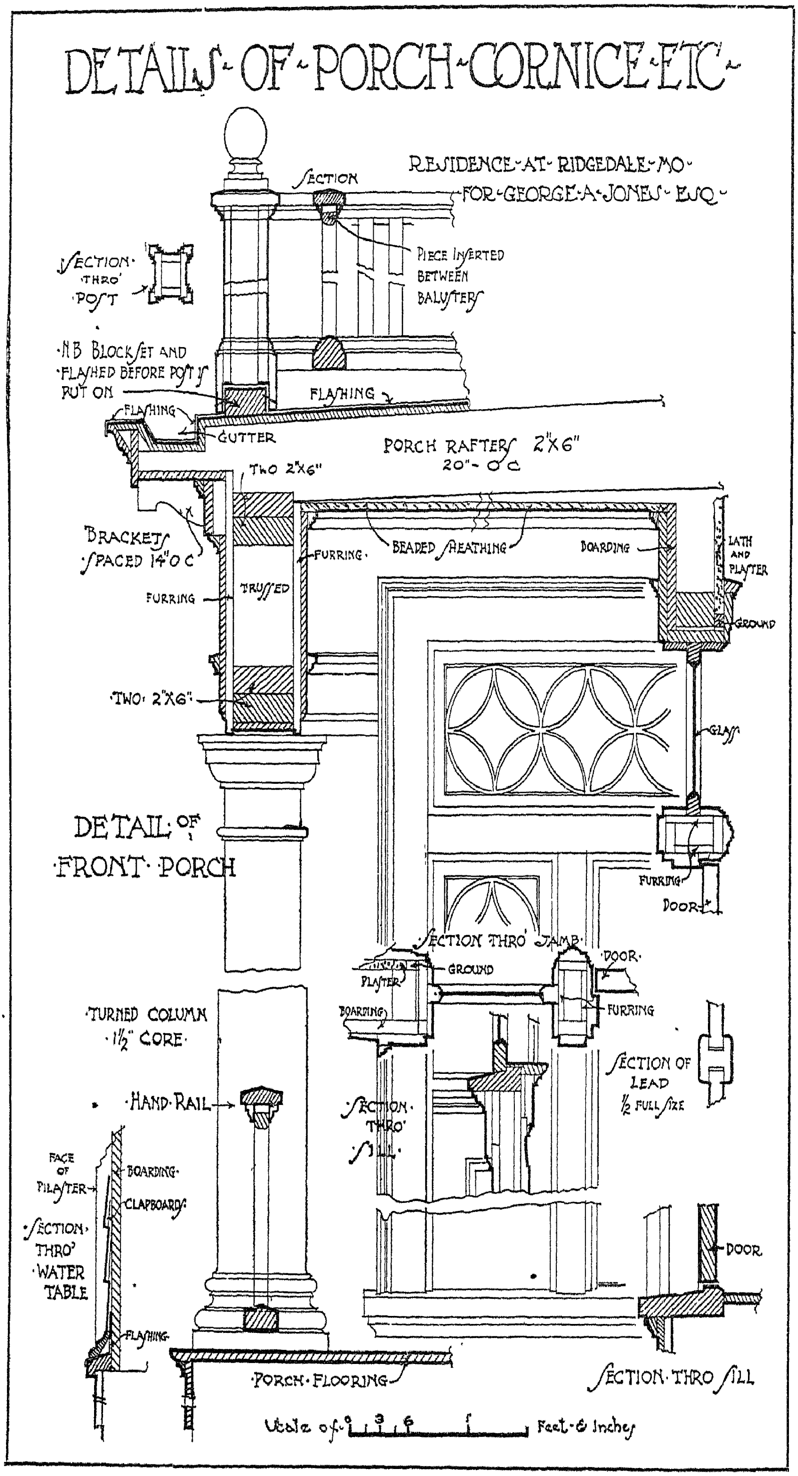

DETAILS OF PORCH CORNICE ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
SECTION
PIECE INSERTED BETWEEN BALUSTERS
SECTION THRO' POST
N B BLOCK SET AND FLASHED BEFORE POST IS PUT ON
FLASHING
FLASHING
GUTTER
PORCH RAFTERS 2"X6" 20" O C
TWO 2"X6"
BRACKETS SPACED 14" O C
FURRING
TRUSSED
FURRING
BEADED SHEATHING
BOARDING
LATH AND PLASTER
GROUND
TWO 2"X6"
GLASS
DETAIL OF FRONT PORCH
FURRING
DOOR
SECTION THRO' JAMB
PLASTER
GROUND
DOOR
BOARDING
FURRING
TURNED COLUMN 1½" CORE
SECTION OF LEAD ½ FULL SIZE
HAND RAIL
SECTION THRO' SILL
FACE OF PILASTER
BOARDING
CLAPBOARDS
SECTION THRO' WATER TABLE
FLASHING
DOOR
PORCH FLOORING
SECTION THRO SILL
Scale of 0 3 6 1 Feet & Inches

Fig. 16.

Brought forward		$2 14	$137 54
Two Low Doors—			
2 pairs butts, 2½ × 2½-inch, at	$.10 each	20	
2 cupboard turns, at	$.35 each	70	
Labor		1.00	
Windows—			
8 sash fasts, at	$.30 each	2.40	
16 sash lifts, at	$.06 each	96	
Labor		4 00	
6 doz. H. & C. hooks, 639½, at	$ 50 doz	3 00	
3 doz. base knobs, at	$ 35 doz.	1 05	
Labor		2 50	$ 17.95
Total cost of Hardware put on			$155.49

HEATING

Furnace—			
1 No. 28 Crawford furnace (28-in. firepot)		$125 00	
22 ft. 8-in. galv. iron smoke-pipe, 55 lbs., at	$ 09 lb.	4.95	
Registers—			
1 14 × 18-in. register, stone, box and netting,		4 72	
4 9 × 12-in. registers, stone, box and netting, at	$1.57 each	6 28	
4 8 × 10-in. registers, stone, box and netting, at	$1.19 each	4.76	
4 8 × 10-in. registers, stone, box and netting, at	$1.15 each	4.60	
Piping, including dampers, collars, and elbows—			
12 ft. 14-in. tin pipe, at	$.27 per ft.	3 24	
64 ft. 9-in. " " at	$.16 " "	10 24	
278 ft. 7-in. " " at	$ 10 " "	27.80	
Covering for Risers (6 lbs. asbestos paper per pipe)—			
5 risers, 30 lbs., at $.05 lb.		1.50	
Plastering Rings in Cellar—			
For 13 pipes at $.20 each		2.60	
		$ 195 69	
Office expense and profit		48.92	$244.61
Carried forward			$244.61

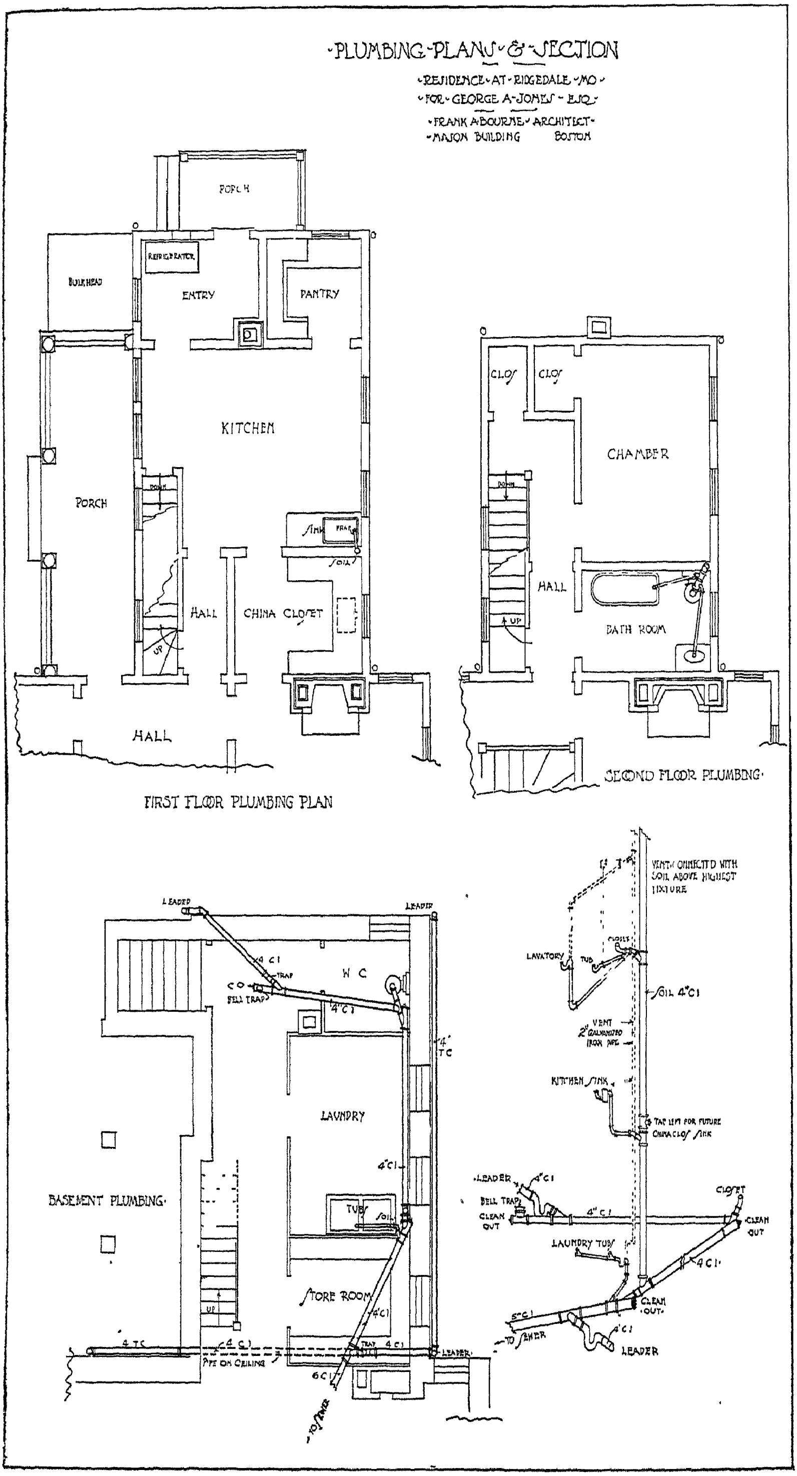

PLUMBING PLANS & SECTION
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
PORCH
REFRIGERATOR
BULKHEAD
ENTRY
PANTRY
KITCHEN
PORCH
DOWN
SINK
TRAP
SOIL
HALL
CHINA CLOSET
UP
HALL
FIRST FLOOR PLUMBING PLAN
CLOS
CLOS
CHAMBER
DOWN
HALL
UP
BATH ROOM
SECOND FLOOR PLUMBING
LEADER
LEADER
4 C I
TRAP
W C
C O
BELL TRAP
4 C I
4 T C
LAUNDRY
4 C I
BASEMENT PLUMBING
TUBS
SOIL
STORE ROOM
4 C I
UP
4 T C
4 C I
PIPE ON CEILING
TRAP
4 C I
LEADER
6 C I
TO SEWER
VENTS CONNECTED WITH SOIL ABOVE HIGHEST FIXTURE
CLOSET
LAVATORY
TUB
SOIL 4" C I
VENT
2" GALVANIZED IRON PIPE
KITCHEN SINK
TAP LEFT FOR FUTURE CHINA CLOS SINK
LEADER
4" C I
BELL TRAP
CLEAN OUT
4" C I
CLOSET
CLEAN OUT
LAUNDRY TUBS
4 C I
CLEAN OUT
5" C I
TO SEWER
4" C I
LEADER

Fig. 17.

Brought forward		$244.61
LABOR—		
Measuring and laying out risers, man 1 day .	$4.80	
Erecting risers, man 2 days, helper 1 day. . .	12 00	
Laying out and erecting cellar pipes and furnace, man 3 days, helper 2 days	19.20	
Finishing, man 1 day	4.80	
Carting and expenses	10.00	50.80
Total cost of Heating Apparatus . .		$ 295.41

PLUMBING

WASTE AND SOIL PIPES—		
2 4-in. lead bends, at $1.10 each .	$2 20	
2 4-in. sleeves, at $.65 each	1 30	
5 2-in. " at $.28 each	1.40	
2 3 × 2-in. sleeves, at $ 45 each . .	90	
1 1½-in. Pemberton trap.	6 80	
30 lbs. solder, wiping, at $.25 lb . .	7 50	
2 trap plugs, at $.42 each . . .	.84	
2 6-in. traps, at $2.35 each	4 70	
1 6-in. cesspool	3.00	
4 1½-inch solder nipples, at $ 15 each .	.60	
1 4-in. roof flashing	1 35	
Soil pipe	47.87	
15 ft. 1½-in. lead pipe, No. 55	3.24	
50 ft. 2-in. iron pipe 40 ft. 1½-in. " "	8.96	
Soil fittings, ⅓ cost of pipe	15.96	
Cast-iron fittings, 20 per cent	1.79	$ 108.41
MISCELLANEOUS FITTINGS—		
3 4-in. brass C. O.	$ 2.70	
1 5-in. brass C. O	1.50	
Refrigerator waste	12.50	
Local vents	12.00	
1 ball-cock	1.25	
2 sill cocks	2.00	
Tank overflow	6.50	
4 ¾-inch S. & W. cocks	3.24	
Carried forward	$41.69	$108.41

Brought forward		$ 41.69	$ 108 41
1 boiler valve and chain		.70	
25 lbs. tinned copper, at $.32 lb.		8.00	
6 3-part hangers, brass		6.30	
2 ¾-in. hose bibs		1.50	
3 ¾-inch plain bibs		2 10	
Street connections		55 00	
1 lb. putty		05	
2 lbs. grafting wax		.50	
Calking lead, 380 lbs.		22.80	
Oakum		1.60	$ 140.24
FIXTURES—			
1 36 x 24 x 8-in. sink, 12-in. back		$11.40	
1 24 x 14-in. pantry sink		14.00	
1 pair pantry cocks		3.60	
2 24 x 48-in. trays, 12-in. back		14.10	
1 5-ft. bathtub, complete		41.00	
1 lavatory, complete		32.50	
1 water-closet, complete		60.00	
1 40-gallon boiler		16.75	
1 " " " stand		.85	
12 lbs. fine solder		3 12	
Clamps and hooks		2.70	
Tinned tacks		.15	
Fuel		1.95	$ 202.12
SUPPLIES AND LABOR—			
126 ft. ¾-inch galv. water pipe		$4.41	
22 ft. ½-inch " " "		.62	
Fittings, ⅓ cost of pipe		1.67	
74 ft. ¾-in. brass	$23.49		
56 ft. ½-in. "	16.24	39.73	
Fittings, 20 per cent		7.95	
Painting of iron pipes		9 75	
Stop-cocks		3 54	
Sink and tray legs		4.72	
Lead, oil, etc.		.65	
Carried forward		$ 73.04	$ 450.77

Brought forward	$ 73 04	$ 450.77
Clamping brass and screws	.25	
Cartage and fares	5 00	
Labor, 40 days, at $6.00 per day	240.00	318 29
		$ 769.06
Profit, 10 per cent		76.90
Total cost of Plumbing.		$ 845.96

ELECTRIC WIRING

75 ft.	No. 4 S. B. R.C. wire	$ 4.80
150 ft.	No. 1 S. B. R. C. wire	4 26
40	Large porcelain tubes, 5 cents	2.00
30	" " knobs, 5 cents	1.50
1	3-pole 50-amp. fused switch	1.50
1	Main cabinet (meter)	3.50
1	8-circuit cut-out panel	16.00
2,500 ft.	No. 14 S.B. R.C. wire	28.60
500 ft.	1 4-in. circular loom	20.00
800	5½ knobs	3.20
1,600	5-in. porcelain tubes	4.00
100	Fire stops	9.00
100	12-in. porcelain tubes	10.00
18	Ceiling boxes	1.80
30	Bracket boxes	3.00
11	Switch boxes	2.20
11	" "	12.10
	Labor on No. 14 wire	55.00
	" " mains	15.00
	" " finish	15.00
	Teaming and freight	5.00
	Sundries	5.00
	Nails, leatherheads, etc.	3.00
		$ 225.46
	Office expense, 10 per cent	22.55
		$ 248.01
	Profit, 20 per cent	49.60
	Total cost of Electric Wiring	$ 297.61

NOTE.—This estimate is figured on outlet boxes at all outlets; and includes a main cabinet and main switch to connect with the meter and to cover the meter, on an eight-circuit panel-board, which allows one spare circuit. The panel-board is to be made of slate, with slate gutters and linings, with good wood door and trim.

The labor is estimated on wages being $3.60 per day for a journeyman, and $2.00 per day for helper. This price is above that paid in small places, but is below what is paid in some cities.

ELECTRIC LIGHTING FIXTURES

NOTE.—While the electric lighting fixtures are not generally made a part of the building contract, it may be worth while to consider them in relation to the cost of the house; although, as has been stated, there is such a wide range in design and cost, as well as in personal preference, that any data given can be at best only approximate.

The following estimate is based upon simple designs of moderate cost in "old brass" finish:

FIRST STORY

LIVING ROOM—	
1 4-light electrolier	$17.50
4 1-light wall brackets, at $3.25 each	13.00
HALL—	
2 2-light ceiling pieces, at $2.50 each	5.00
VESTIBULE—	
1 3-light cluster	5.00
PORCH—	
1 1-light ceiling-piece	1.75
PARLOR—	
1 4-light electrolier	17.50
2 1 " wall brackets	6.50
DINING ROOM—	
1 4-light electrolier	10.00
2 1 " wall brackets	5.00
CHINA CLOSET, REAR HALL, KITCHEN—	
3 1-light ceiling-pieces, at $.75 each	2.25
2 1 " wall brackets, at $1.35 each	2.70
Carried forward	$86.20

Brought forward	$ 86.20
PANTRY—	
1 1-light ceiling-piece	.75
ENTRY—	
1 1 “ “ “	1.35
PIAZZA—	
1 1 “ “ “	1.75

SECOND STORY

HALL—	
2 1-light ceiling-pieces, at $1.50 each	$3.00
ALCOVE—	
2 1-light ceiling pieces, at $2.50 each	5.00
BEDROOMS—	
13 1-light brackets, at $2.50 each	32.50
BATHROOM—	
1 1-light ceiling-piece	1.35
REAR HALL—	
1 1-light bracket	1.35

THIRD STORY

HALL—	
1 1-light wall bracket	$1.35
ATTIC—	
1 3-ft. drop-cord	.85

BASEMENT

LAUNDRY—	
1 1-light wall bracket	$1.15
CELLAR—	
4 3-ft. drop-cords, at $.85 each	3.40
	$ 140.00

LABOR

Installing above fixtures with all necessary trimmings	$ 12.00
Total cost of Electric Lighting Fixtures in place	$152.00

PAINTING

OUTSIDE PAINTING—	
17 pairs blinds, three coats painting, at $1.50 pair	$ 25.50
1,068 yds. three coats painting, windows and woodwork, at $ 20 yd.	213.60
Carried forward	$239.10

Brought forward	$239.10
54 yds. two coats metallic paint, upper side tin roofs, at $.15 yd.	8.10
62 yds. two coats oiling on floors, porch, and piazza, at $.10 yd....	6.20
INTERIOR PAINTING—	
166 yds. filling, staining, and shellacing, and two coats hard oil finish, at $ 20 yd.	$33 20
245 yds. filling and two coats spar varnish, first coat rubbed, at $.25 yd.	61.25
403 yds. one coat shellac, three of paint, two coats zinc and white varnish. Rubbed with pumice and water, ivory white finish, at $ 80 yd.	322.40
294 yds. treat with potash, one oil filler, clean, four coats shellac, last coat rubbed with pumice and oil, oak and birch, at $.35 yd.	102 90
109 yds. filling, four coats shellac, last coat rubbed with pumice and oil, floors at $ 30 yd.	32 70
114 yds. size and three coats paint, last coat with varnish, walls, at $ 20 yd.	22 80
5 yds. three coats paint and one enamel gloss, bathtub, at $.25 yd.	1.25
100 yds. three coats paint, last with zinc, flat, whitewood, at $.25 yd.	25.00
10 yds. one coat shellac on pipes, at $ 10 yd.	1.00
299 yds. size and tint in water-colors, ceilings, at $.15 yd.	44.85
Total cost of Painting	$ 900.75

GENERAL SUMMARY

Batter-Boards and Water Supply	$ 25.00
Excavation	262.50
Stonework, Cesspools, and Drains	754.15
Chimneys and Brickwork	281.50
Concreting	88.20
Plastering	544.40
Carpenter Work	4,928.34
Carried forward	$6,884.09

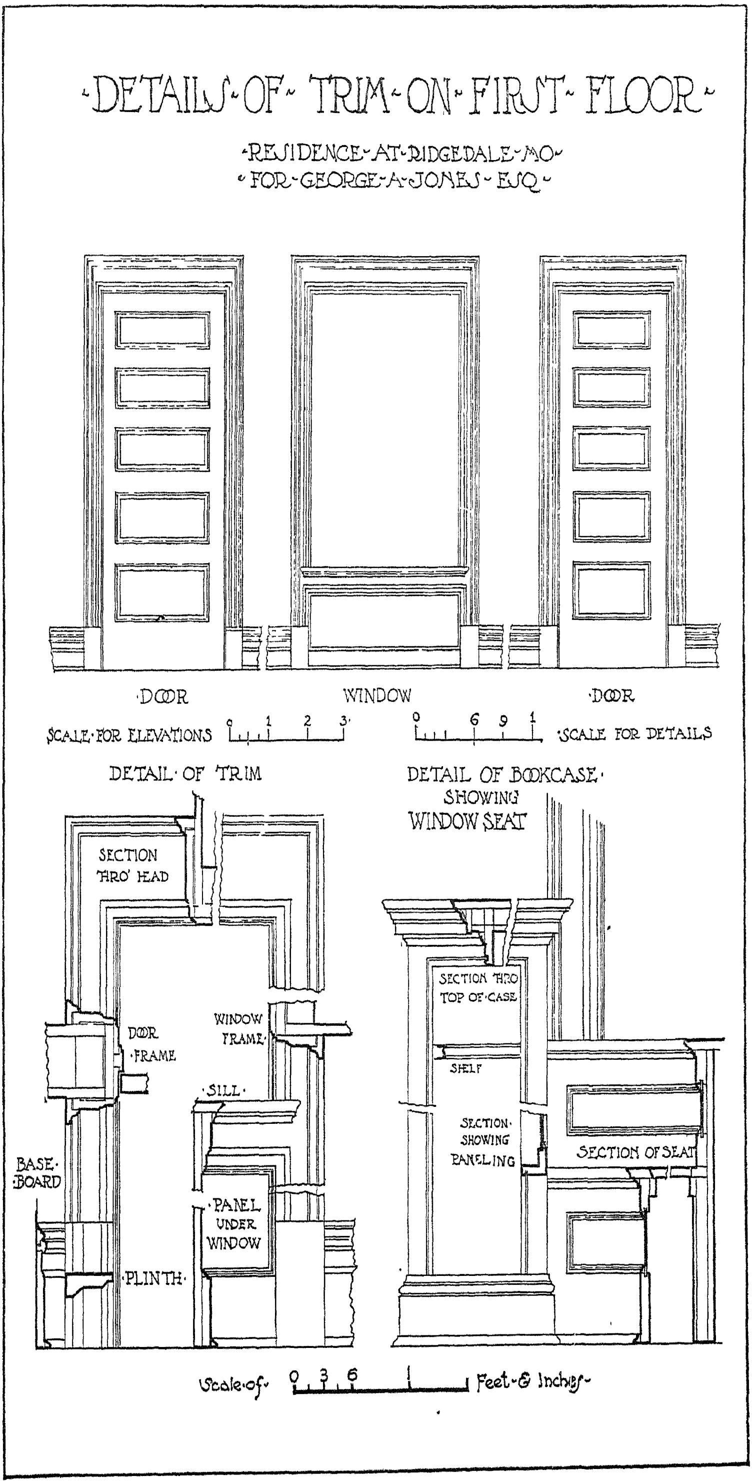

DETAILS OF TRIM ON FIRST FLOOR
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
DOOR
WINDOW
DOOR
SCALE FOR ELEVATIONS 0 1 2 3'
0 6 9 1 SCALE FOR DETAILS
DETAIL OF TRIM
DETAIL OF BOOKCASE SHOWING WINDOW SEAT
SECTION THRO' HEAD
DOOR FRAME
WINDOW FRAME
SILL
BASE BOARD
PANEL UNDER WINDOW
PLINTH
SECTION THRO TOP OF CASE
SHELF
SECTION SHOWING PANELING
SECTION OF SEAT
Scale of 0 3 6 1 Feet & Inches

Fig. 18.

Brought forward	$6,884 09
Stairs	216 21
Hardware	155.49
Heating	295 41
Plumbing	845.96
Electric Wiring	297.61
Electric Fixtures	152 00
Painting	900 75
Total,	$9,747.52

SCHEDULES

ANALYSIS OF CARPENTER WORK

Following is a section devoted to the analysis of the different portions of carpenter work in the foregoing estimate. These show how the prices are obtained, and will be very useful for comparison, as the changes in cost of parts can be noted and kept up to date.

First Floor, price per square of 100 sq. ft., including the floor beams, bridging, and under floors, but no furring for plaster—

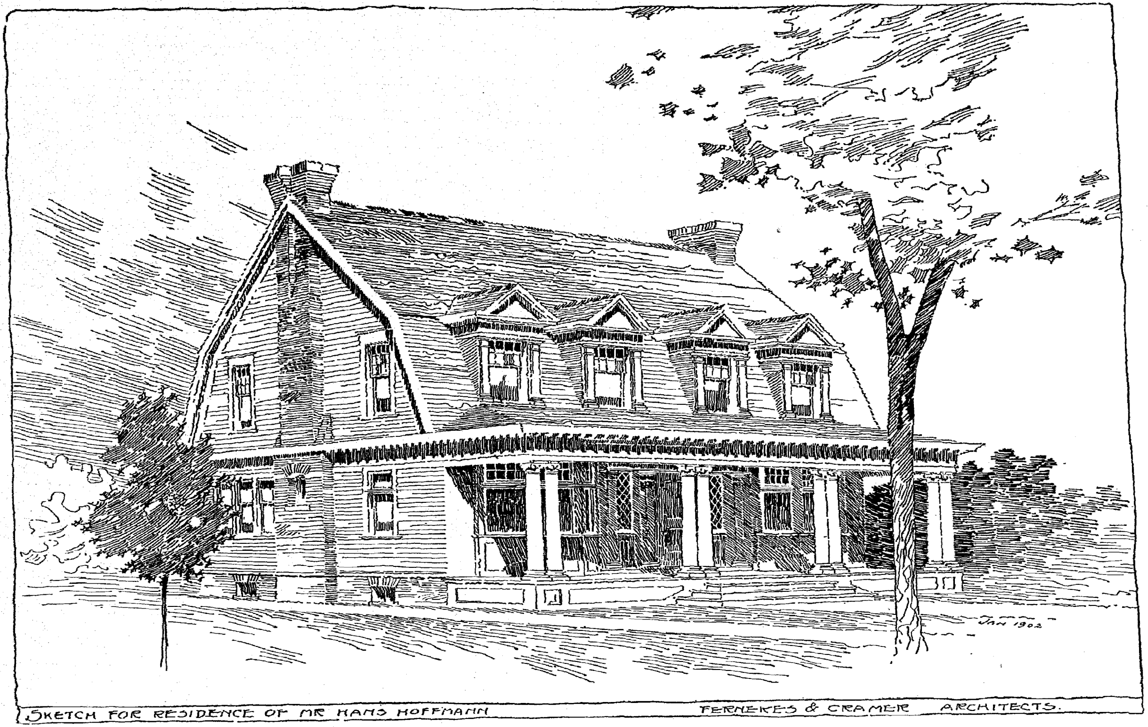
Joists, 2 × 10-in., 16 inches on centers	$3.25	
Labor	1.50	
Nails	10	
Bridging	.50	
Under floor, hemlock, at $24.00	2.30	
Waste, one-third	.80	
Labor	.75	
Nails	.15	$ 9.35

Hard Pine Upper Floor, per square of 100 sq. ft.—

Stock	$6.00	
Waste, one-third	2 00	
Labor	2.25	
Nails	.25	$10.50

Quartered Oak Upper Floor, per square of 100 sq. ft.—

Stock	$10.00	
Waste	3 30	
Labor	6 50	
Nails	.25	$20.05


JAN 1902
SKETCH FOR RESIDENCE OF MR HANS HOFFMANN
FERNEKES & CRAMER ARCHITECTS.

RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

Fernekes & Cramer, Architects

For Plans, See Page 314.

Porch or Veranda Floor, per square of 100 sq. ft.—

Joists, 2 × 8-in., 16 inches on centers	$2.60	
Labor	1.00	
Hard pine flooring, at $55.	5.50	
Waste	1.80	
Labor	1.25	
Nails	.20	$12.35

Second Floor, per square of 100 sq. ft.—

Joists, 2 × 10-in., 16 inches on centers	$3 25	
Labor	1.50	
Bridging	.50	
Furring	1.50	
Under-floor stock	2.30	
Waste, one-third	.80	
Labor	.75	
Nails	.15	
Upper-floor stock	4.00	
Waste	1.30	
Labor	1.75	
Nails	.20	$18.00

Third Floor, per square of 100 sq. ft.—

Joists, 2 × 8-in., 16 inches on centers	$ 2.60	
Labor	1.50	
Under floor	4.00	
Furring	1.50	
Bridging	.50	$10.10

Shingled Roof, per square of 100 sq. ft—

Rafters, 2 × 7-in, 20 inches on centers	$ 2.17	
Labor	2.25	
Matched spruce boarding	2.50	
Waste, one-third	.80	
Labor	1.25	
Nails	.20	
Shingles	4.00	
Labor	3.25	
Nails	.25	$16.67

Tinned Roof, per square of 100 sq. ft.—		
Rafters, 2 × 7-in., 20 inches on centers	$ 2 17	
Labor	1 50	
Matched boarding, as above	4 75	
Paper	.50	
Tinning	12.00	$20.92
Wall Frame and Boarding, per square of 100 sq. ft.—		
Studding, 2 × 4-in., 16 inches on centers	$ 4.00	
Boarding	2 30	
Waste	.80	
Labor	1.00	
Nails	.20	$ 8.30
Inside Studding, per square of 100 sq. ft.—		
Stock, 2x4-in., 16 inches on centers	$ 1.30	
Waste, one-half stock	.65	
Labor	1.50	
Nails	.15	
Grounds and beads	.40	$ 4.00
Clapboarding, per square of 100 sq. ft.—		
Clapboards, 80, at $.05 each	$ 4.00	
Labor	3.25	
Paper	.50	
Nails	.20	$ 7.95
Main Cornice, per linear foot—		
Gutter, per ft.	$ .12	
Upper fascia	.03	
Fillet	.01	
Lower fascia	.04	
Planceer	.08	
Bed-mould	.02	
Frieze	.06	
Architrave moulding	.04	
Brackets	.25	
Labor	.50	
Rough furring	.10	$ 1.25
Piazza Cornice, per linear foot—		
Upper fascia	$ .03	
Carried forward	$ .03	

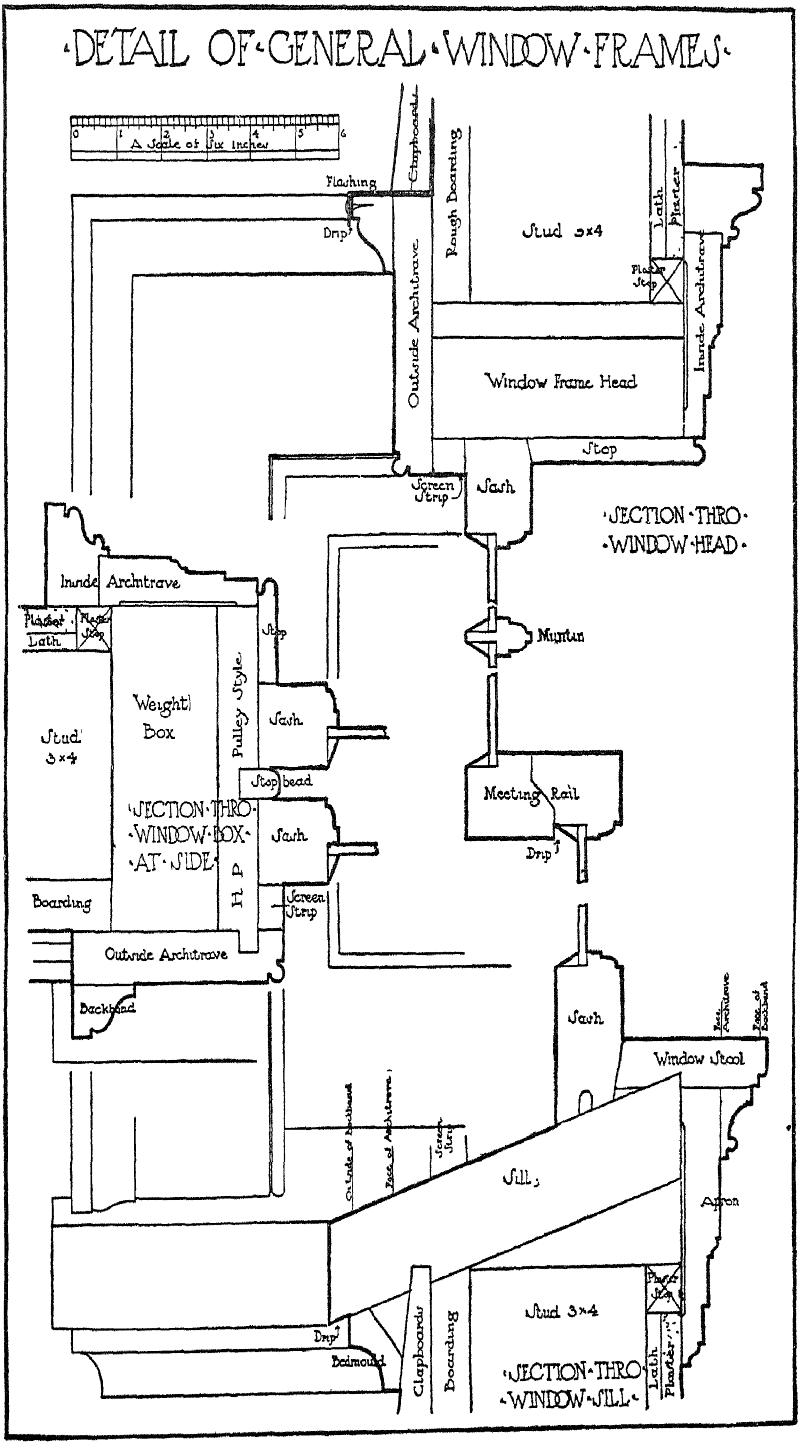

·DETAIL OF·GENERAL·WINDOW·FRAMES·
0 1 2 3 4 5 6
A Scale of Six Inches
Flashing
Drip
Clapboards
Outside Architrave
Rough Boarding
Stud 3×4
Lath
Plaster
Plaster Stop
Inside Architrave
Window Frame Head
Stop
Screen Strip
Sash
·SECTION·THRO·
·WINDOW·HEAD·
Inside Architrave
Plaster
Plaster Stop
Lath
Stop
Muntin
Stud 3×4
Weight Box
Pulley Style
Sash
Stop bead
Meeting Rail
·SECTION·THRO·
·WINDOW·BOX·
·AT·SIDE·
Sash
Drip
H P
Boarding
Screen Strip
Outside Architrave
Backband
Sash
Face of Architrave
Face of Backband
Window Stool
Outside of Backband
Face of Architrave
Screen Strip
Sill
Apron
Plaster Stop
Stud 3×4
Drip
Bedmould
Clapboards
Boarding
·SECTION·THRO·
·WINDOW·SILL·
Lath
Plaster

Fig. 19.

Brought forward	$ .03	
Gutter	10	
Lower fascia	03	
Fillet	.01	
Planceer	.08	
Bed-mould	.02	
Brackets	.25	
Frieze	.15	
Architrave mould	.03	
Soffit	.05	
Inside frieze	.10	
Labor	1.00	
Rough furring	.15	$ 2.00
Attic Windows, circular top, each—		
Frame	$ 6 00	
Sash	2.50	
Inside finish	1.00	
Weights and cord	.45	
Labor	1.25	$11.20
Second-Story Windows, 3 ft. 6 in. × 5 ft., each—		
Frame	$ 3.50	
Sashes, 17½ sq. ft., at $.20 per sq. ft.	$ 3 50	
Blinds	1 00	
Blind fasts	.15	
Inside finish	1.19	
Nails and screws	.10	
Weights and cord	.64	
Labor, 1 day	3.25	$13.33
Inside Finish for Window, as above—		
Architrave, 21 ft., at $.03½ per ft.	$ .73	
Back-band, 21 ft., at $.03 " "	.63	
Beads, 17 ft., at $.02 " "	.34	$ 1.70
30 per cent off		.51
		$ 1.19
Weights and Cord for Window, as above—		
Weights, 17½ ft., 2 lbs. per ft., 35 lbs., at $.01¼ per lb.	$ .44	
Cord, 20 ft., at $.01 per ft.	.20	$ 64

Cost of Window, 2 ft. 6 in. x 4 ft. 6 in., each—

Frame	$ 3.50	
Window, 11¼ sq. ft., at $ 20 per sq. ft.	2.25	
Blinds	.75	
Blind fastenings	.15	
Screws and nails	.10	
Weight, 22½ lbs., at $.01¼ per lb.	.28	
Cord	.15	
Inside Casing, 18 ft., at $.03½ per ft.	.63	
Back-band, 18 ft., at $.03 per ft.	.54	
Stop-beads, 14 ft., at $ 02 per ft.	.28	
Labor	3 25	$11.88

French Windows, 4 ft. 6 in × 7 ft. 6 in., each—

Frame	$ 5.00	
Sash, 4 ft. 6 in. × 7 ft. 6 in., 34 sq. ft., at $.20 per sq. ft.	6 80	
Astragal	50	
Nails and screws	.10	
Inside finish	96	
Labor	4 88	$18.24

Window, 3 ft. 4 in. × 5 ft. 6 in. (oak finish), each—

Frame	$ 3 50	
Window, 18 sq. ft., at $ 20 per sq. ft.	3 60	
Blinds	1.00	
Blind fasts	.15	
Nails and screws	.10	
Weights	70	
Finish (oak)	2.64	
Labor, 1½ days	4.88	$16.57

Rear Door, 2 ft. 10 in. × 7 ft. 6 in.—

Frame	$4.00	
Door, 21 sq. ft., at $.25 per sq. ft.	5.25	
Finish	.91	
Labor	3.25	
Nails	.05	$13.46

Front Door, 3 ft. 3 in. × 7 ft. 6 in., with top and side lights—		
Frame—		
Sill, 7 ft., at $ 25 per ft.	$1.75	
Jambs, 23 ft , at $.07 per ft.	1.61	
Mullions and transom bar, 20 ft., at $ 10½ per ft.	2 10	
Outside casing, 23 ft., at $.03½ per ft.	.81	
Mullion casing, 20 ft., at $.02⅒ per ft.	.42	
Labor, ½ price of stock	3.32	
	$10.01	
Door, 3 ft., 3 in. × 7 ft. 6 in.—		
21 sq. ft., at $ 25 per sq. ft.	$5 25	
Side-light panels, 6 ft., at $ 25 per ft.	1 50	
3 sash rims, at $.50 each	1 50	
Leaded glass, 10⅝ sq. ft., at $2.50 per sq. ft.	27 00	
	$35 25	
Inside Finish—		
Stop-beads	$ .28	
Architrave, 24 ft., at $ 04½ per ft.	1 08	
Labor, 3 days	9.75	
	$11.11	
Total cost of front door and frame		$56.37
Door, 2 ft. 8 in. × 7 ft. 6 in. (N. C. pine)—		
Stock door	$3.00	
Frame	1.25	
Threshold	.15	
Nails	.05	
Finish, 39½ ft , at $.04½ per ft.	1.78	
Labor	3.25	$9.48
Pair of Sliding Doors, 6 ft. × 8 ft. (whitewood and birch)—		
Doors, 48 sq ft., at $.50 per sq. ft.	$24 00	
Architrave, 24 ft., birch	2.34	
" 24 ft., whitewood	1.05	
Jambs, 22 ft., birch	1.82	
" 22 ft., whitewood	.85	
Grounds, 22 ft., birch	.50	
Carried forward	$30.56	

Brought forward	$30.56	
Grounds, 22 ft., whitewood	.23	
Chafing strip, 22 ft., birch	33	
22 ft., whitewood	.15	
Astragal, birch and whitewood	1.50	
Sheathing pockets, 96 ft., at $4.75 per square.	4 50	
Labor, 5 days' work	16.25	$53.52

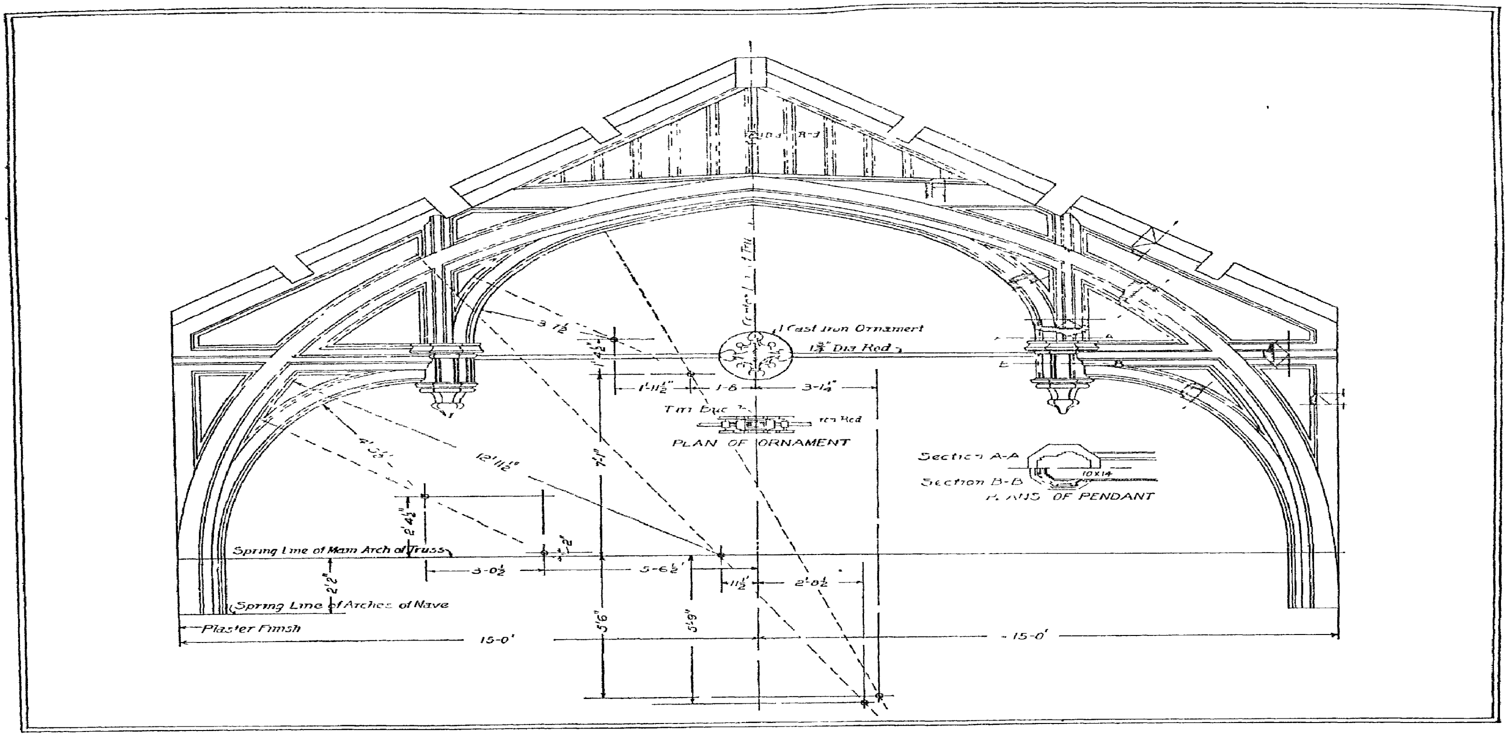
Schedule of Rooms, and Memoranda from which Heating Estimate is Made Up

First Floor Rooms	Size	Contains Cu. Ft.	Divide by	Equals	Size of Register	Area of Pipes	Feet of Tin Pipe, Including Elbows
Living Room.	14×25×9	3,150	25	2 9-in. pipes	2 9×12	128	34
Hall	11×25×9	Add 40% for space above, 3,465	25	14-in. "	14×18	154	12
Parlor	12×14×9	1,512	25	9-in. "	9×12	64	14
Dining Room.	12×14×9	1,512	25	9-in. "	9×12	64	16
China Closet.	7×10×9	....	..	7-in. "	7×10	38	24
Second Floor							
Bedroom	11×14×8½	1,309	35	7-in. "	8×10	38	38
"	11×14×8½	1,309	35	7-in. "	8×10	38	26
"	11×14×8½	1,309	35	7-in. "	8×10	38	40
"	11×14×8½	1,309	35	7-in. "	8×10	38	40
Alcove	6×11×8½	....	..	7-in. "	7×10	38	32
Bathroom....	6×10×8½	....	..	7-in. "	7×10	38	38
Rear Bedroom	10×13×8½	1,105	35	7-in. "	7×10	38	40

Smoke pipe, 22 ft.—Heat-pipe area, 714 sq. in.—Cold-air box, 534 sq. in., or ¾ of heat-pipe area.—Use 28-in. firepot furnace.

Location Sheet of Electric Outlets

LOCATION	CEILING	BRACKET	SW.	TOTAL OUTLETS	TOTAL LIGHTS
Basement—					
Passage	1				1
Furnace	1			1	1
Laundry		1		1	1
Furnace Room	2			2	2
	4	1		4	5
First Floor—					
Entry		1		1	1
Pantry	1			1	1
Kitchen	1	2	2	5	3
Porch	1		1	2	1
China Closet	1			1	1
Dining Room	1	2		3	8
Parlor	1	2		3	10
Hall	1			1	1
Hall	1		2	3	2
Vestibule	1			1	1
Porch	1			1	1
Living Room	1	4	2	7	13
	11	11	7	29	43
Second Floor—					
Back Hall		1	2	3	1
Bedroom		1		1	1
Bath		1		1	1
Bedroom		3		3	3
"		3		3	3
Alcove		2		2	2
Front Hall	2		2	4	2
Bedroom		3		3	3
"		3		3	3
	2	17	4	23	19
Attic—					
Hall		1		1	1
Attic	1			1	1
	1	1		2	2



FINISHED ROOF TRUSS IN FIRST PRESBYTERIAN CHURCH, SYRACUSE, N. Y.
Tracy & Swartwout, Architects; Ballantyne & Evans, Associated.
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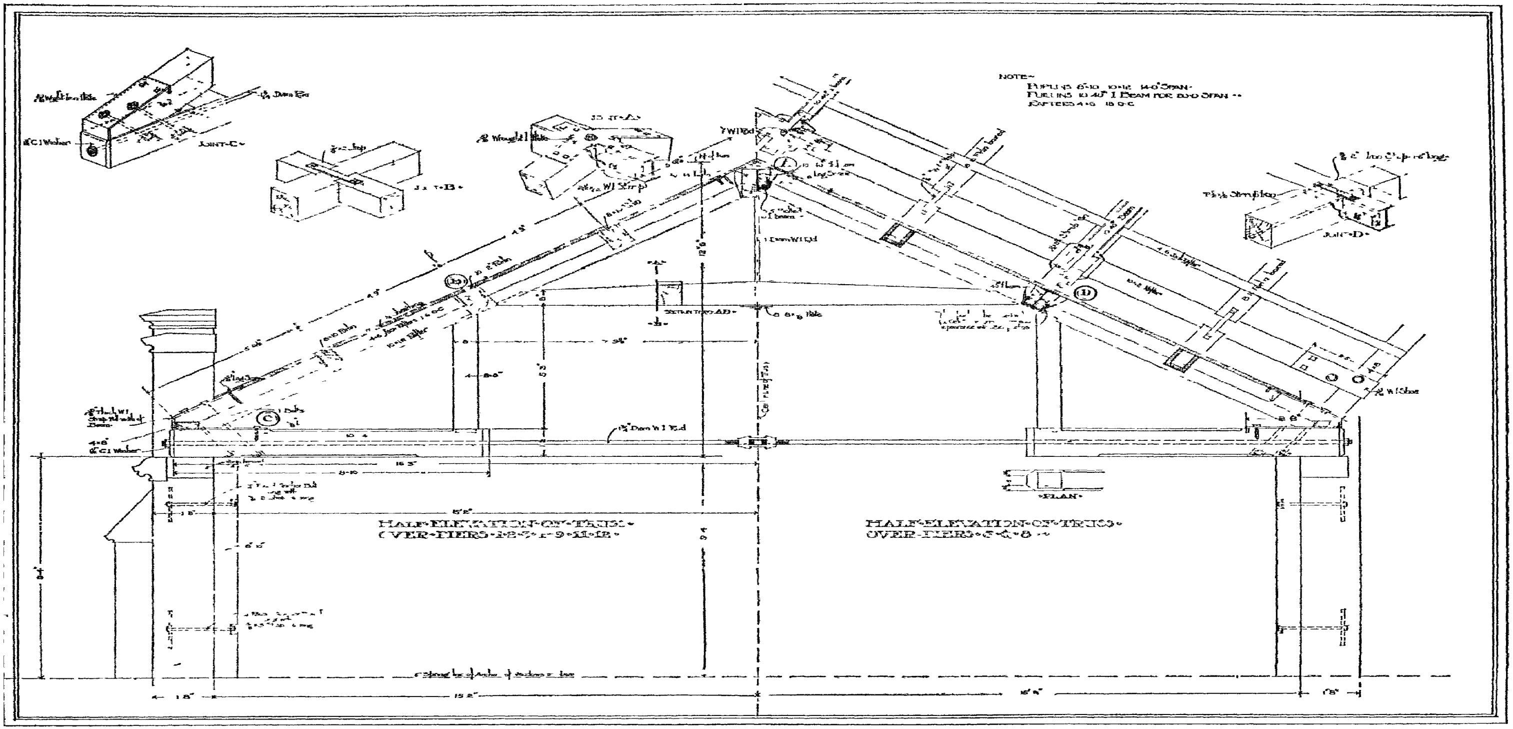

STRUCTURAL WOODEN ROOF TRUSS IN FIRST PRESBYTERIAN CHURCH, SYRACUSE, N. Y.
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THE STEEL SQUARE

INTRODUCTORY

The Standard Steel Square has a *blade* 24 inches long and 2 inches wide, and a *tongue* from 14 to 18 inches long and 1½ inches wide.

The blade is at right angles to the tongue.

The *face* of the square is shown in Fig. 1. It is always stamped with the manufacturer's name and number.

The reverse is the *back* (see Fig. 2).

The longer arm is the *blade;* the shorter arm, the *tongue.*

In the center of the tongue, on the face side, will be found two parallel lines divided into spaces (see Fig. 1); this is the *octagon scale.*

The spaces will be found numbered 10, 20, 30, 40, 50, 60, and 70, when the tongue is 18 inches long.

To draw an octagon of 8 inches square, draw a square 8 inches each way, and draw a perpendicular and a horizontal line through its center.

To find the length of the octagon side, place one point of a compass on any of the main divisions of the scale, and the other point of the compass on the eighth subdivision; then step this length off on each side of the center lines on the side of the square, which will give the points from which to draw the octagon lines.

The diameter of the octagon must equal in inches the number of spaces taken from the square.

On the opposite side of the tongue, in the center, will be found the *brace rule* (see Fig. 3). The fractions denote the *rise* and *run* of the brace, and the decimals the *length.* For example, a brace of 36 inches run and 36 inches rise, will have a length of 50.91 inches; a brace of 42 inches run and 42 inches rise, will have a length of 59.40 inches; etc.

On the back of the blade (Fig. 4) will be found the *board measure,* where eight parallel lines running along the length of the blade are shown and divided at every inch by cross-lines. Under 12, on the outer edge of the blade, will be found the various lengths of the boards, as 8, 9, 10, 11, 12, etc. For example, take a board 14 feet long and 9

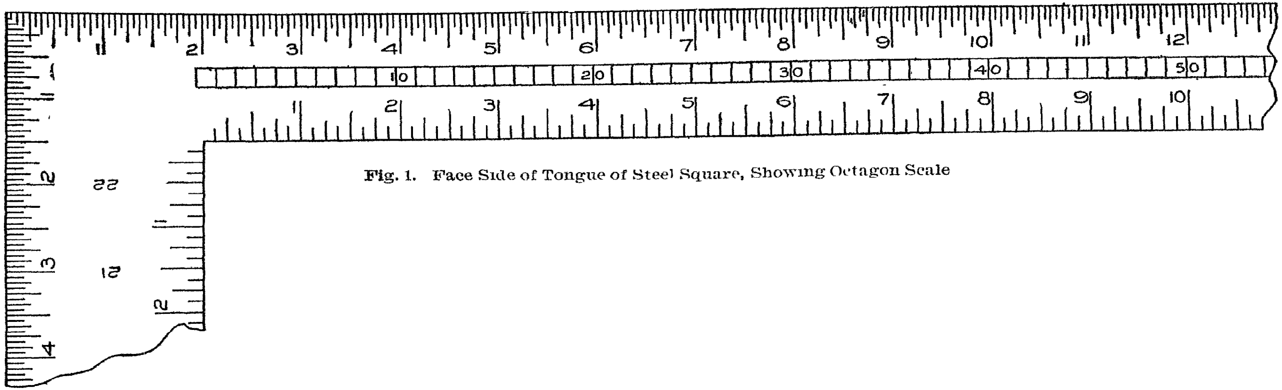
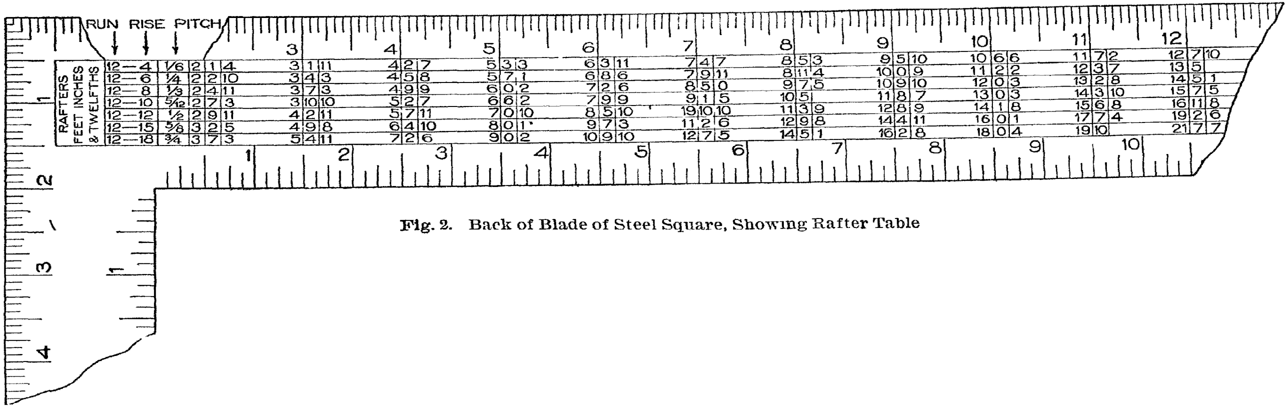


Fig. 1. Face Side of Tongue of Steel Square, Showing Octagon Scale



RUN — RISE	PITCH		3	4	5	6	7	8	9	10	11	12
12—4	1/6	2 1 4	3 1 11	4 2 7	5 3 3	6 3 11	7 4 7	8 5 3	9 5 10	10 6 6	11 7 2	12 7 10
12—6	1/4	2 2 10	3 4 3	4 5 8	5 7 1	6 8 6	7 9 11	8 11 4	10 0 9	11 2 2	12 3 7	13 5
12—8	1/3	2 4 11	3 7 3	4 9 9	6 0 2	7 2 6	8 5 0	9 7 5	10 9 10	12 0 3	13 2 8	14 5 1
12—10	5/12	2 7 3	3 10 10	5 2 7	6 6 2	7 9 9	9 1 5	10 5	11 8 7	13 0 3	14 3 10	15 7 5
12—12	1/2	2 9 11	4 2 11	5 7 11	7 0 10	8 5 10	19 10 10	11 3 9	12 8 9	14 1 8	15 6 8	16 11 8
12—15	5/8	3 2 5	4 9 8	6 4 10	8 0 1	9 7 3	11 2 6	12 9 8	14 4 11	16 0 1	17 7 4	19 2 6
12—18	3/4	3 7 3	5 4 11	7 2 6	9 0 2	10 9 10	12 7 5	14 5 1	16 2 8	18 0 4	19 10	21 7 7

Fig. 2. Back of Blade of Steel Square, Showing Rafter Table

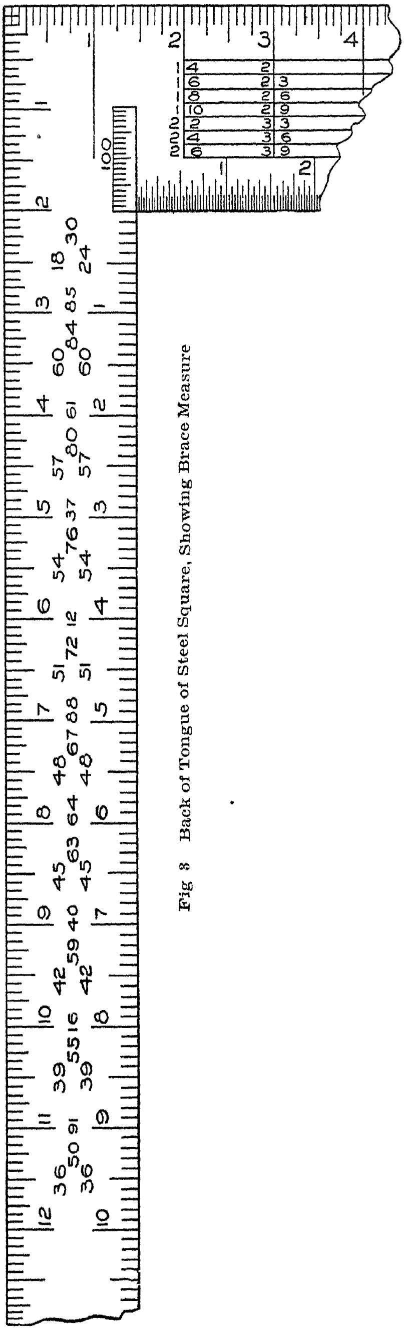


Fig 3 Back of Tongue of Steel Square, Showing Brace Measure

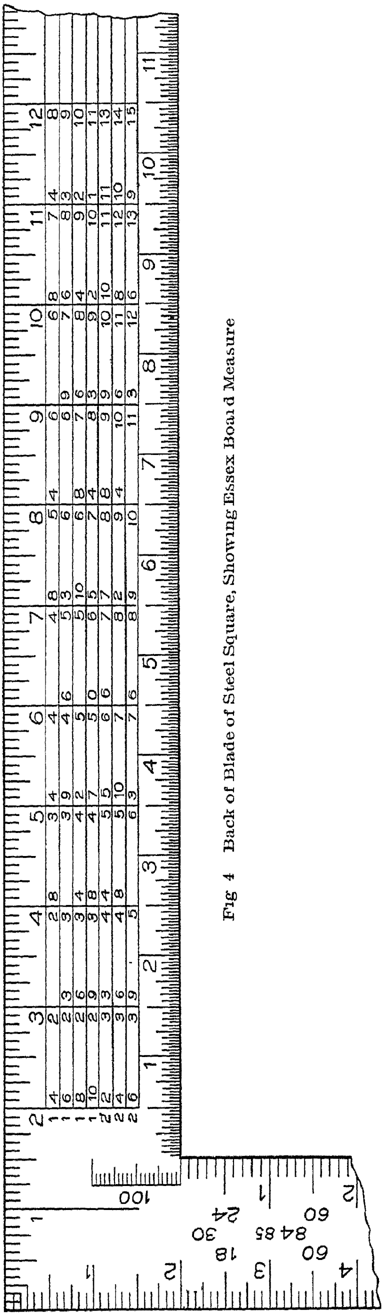


Fig 4 Back of Blade of Steel Square, Showing Essex Board Measure

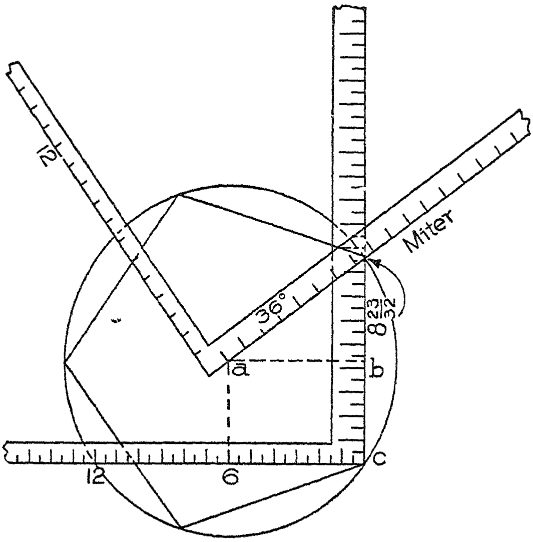


Fig. 5. Use of Steel Square to Find Miter and Side of Pentagon.

inches wide. To find the contents, look under 12, and find 14; then follow this space along to the cross-line under 9, the width of the board; and here is found 10 feet 6 inches, denoting the contents of a board 14 feet long and 9 inches wide.

To Find the Miter and Length of Side for any Polygon, with the Steel Square. In Fig. 5 is shown a pentagon figure. The miters of the pentagon stand at 72 degrees with each other, and are found by dividing 360 by 5, the number of sides in the pentagon. But the angle when applied to the square to obtain the miter, is only one-half of 72, or 36 degrees, and intersects the blade at $8\frac{23}{32}$, as shown in Fig. 5.

By squaring up from 6 on the tongue, intersecting the degree line at *a*, the center *a* is determined either for the inscribed or the circumscribed diameter, the radii being *a b* and *a c*, respectively.

The length of the sides will be $8\frac{23}{32}$ inches to the foot.

If the length of the inscribed diameter be 8 feet, then the sides would be $8 \times 8\frac{23}{32}$ inches.

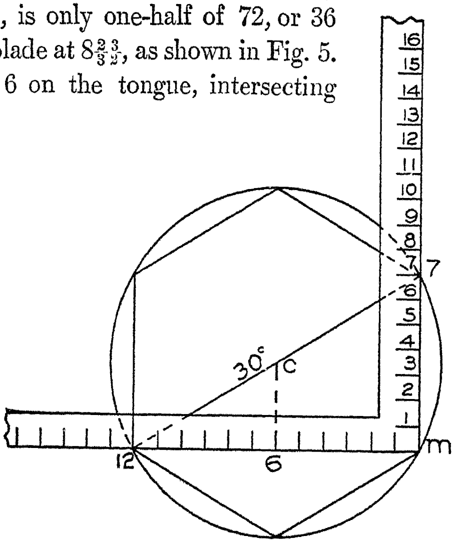


Fig. 6. Use of Steel Square to Find Miter and Side of Hexagon.

The figures to use for other polygons are as follows:

Triangle	$20\frac{25}{32}$
Square	12
Hexagon	7
Nonagon	$4\frac{3}{8}$
Decagon	$3\frac{7}{8}$

In Fig. 6 the same process is used in finding the miter and side of the hexagon polygon.

To find the degree line, 360 is divided by 6, the number of sides, as follows:

$360 \div 6 = 60$; and $60 \div 2 = 30$ degrees.

Now, from 12 on tongue, draw a line making an angle of 30 degrees with the tongue. It will cut the blade in 7 as shown; and from 7 to *m*, the heel of the square, will be the length of the side. From 6 on tongue, erect a line to cut the degree line in *c;* and with *c* as center, describe a circle having the radius of *c* 7; and around the circle, complete the hexagon by taking the length 7 *m* with the compass for each side, as shown.

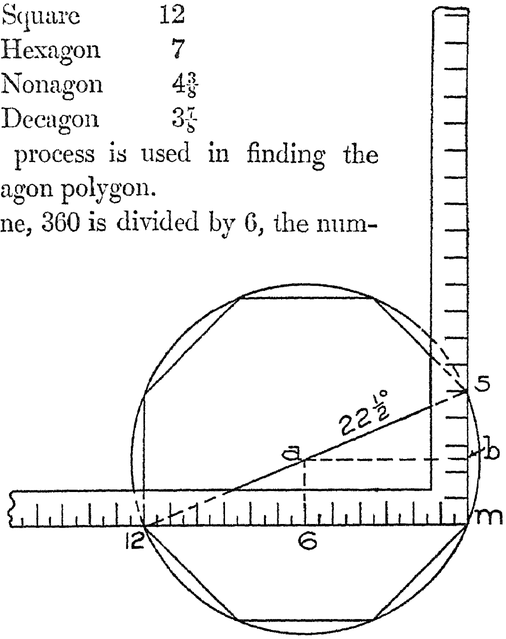


Fig. 7. Use of Steel Square to Find Miter and Side of Octagon.

In Fig. 7 the same process is shown applied to the octagon. The degree line in all the polygons is found by dividing 360 by the number of sides in the figure:

$360 \div 8 = 45$; and $45 \div 2 = 22\frac{1}{2}$ degrees.

This gives the degree line for the octagon. Complete the process as was described for the other polygons.

By using the following figures for the various polygons, the miter lines may be found; but in these figures no account is taken of the relative size of sides to the foot as in the figures preceding:

Triangle	7	in.	and	4 in.
Pentagon	11	"	"	8 "
Hexagon	4	"	"	7 "
Heptagon	$12\frac{1}{2}$	"	"	6 "

Octagon	17 in.	and	7 in.
Nonagon	22½ "	"	9 "
Decagon	9½ "	"	3 "

The miter is to be drawn along the line of the first column, as shown for the triangle in Fig. 8, and for the hexagon in Fig. 9.

In Fig. 10 is shown a diagram for finding degrees on the square. For example, if a pitch of 35 degrees is required, use $8\frac{13}{32}$ on tongue and 12 on blade; if 45 degrees, use 12 on tongue and 12 on blade; etc.

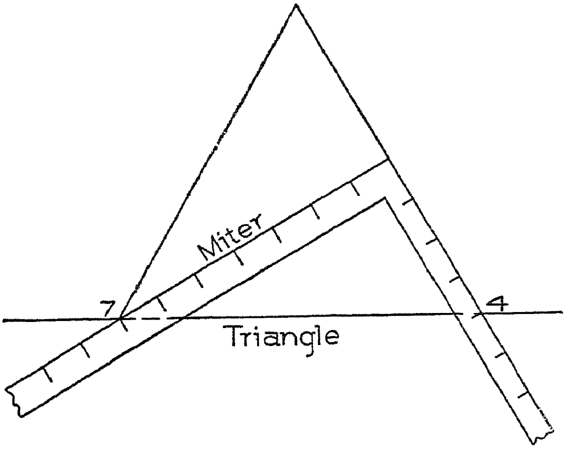


Fig. 8. Use of Square to Find Miter of Equilateral Triangle

In Fig. 11 is shown the relative length of run for a rafter and a hip, the rafter being 12 inches and the hip 17 inches. The reason, as shown in this diagram, why 17 is taken for the run of the hip, instead of 12 as for the common rafter, is that the seats of the common rafter and hip do not run parallel with each other, but diverge in roofs of equal pitch at an angle of 45 degrees; therefore, 17 inches taken on the run of the hip is equal to only 12 inches when taken on that of the common rafter, as shown by the dotted line from heel to heel of the two squares in Fig. 11.

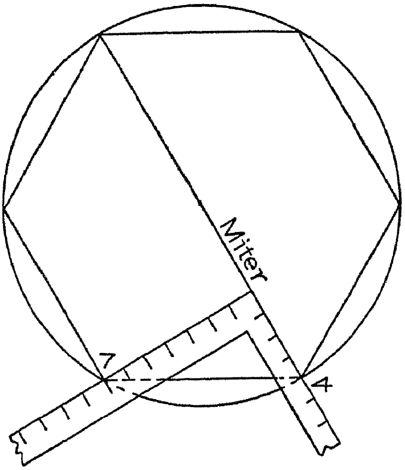


Fig. 9. Use of Square to Find Miter of Hexagon.

In Fig. 12 is shown how other figures on the square may be found for corners that deviate from the 45 degrees. It is shown that for a pentagon, which makes a 36-degree angle with the plate, the figure to be used on the square for run is $14\frac{7}{8}$ inches; for a hexagon, which makes a 30-degree angle with the plate, the figure will be $13\frac{7}{8}$ inches; and for an octagon, which makes an angle of $22\frac{1}{2}$ degrees with the plate, the figure to use on the square for run of hip to correspond to the run of the common rafters, will be 13 inches. It will be observed that the height in each case is 9 inches.

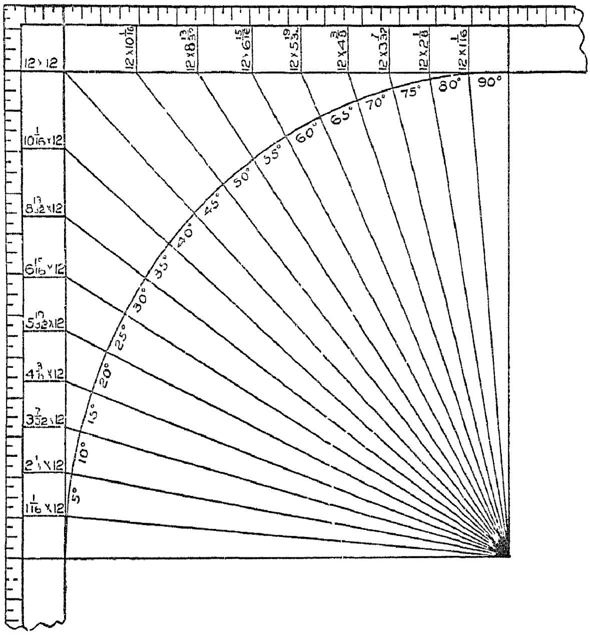


Fig 10. Diagram for Finding Pitches of Various Degrees by Means of the Steel Square

Fig. 13 illustrates a method of finding the relative height of a hip or valley per foot run to that of the common rafter. The square is shown placed with 12 on blade and 9 on tongue for the common rafter; and shows that for the hip the rise is only $6\frac{6}{7}$ inches.

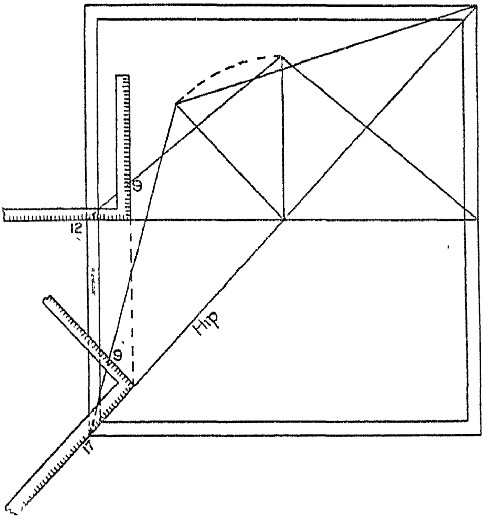


Fig. 11. Square Applied to Determine Relative Length of Run for Rafter and Hip

The Steel Square as Applied in Roof Framing. Roof framing at present is as simple as it possibly can be, so that any attempt at a new method would be superfluous. There may, however, be a certain way of presenting the subject that will carry with it almost the weight assigned to a new theory, making what is already simple still more simple.

The steel square is a mighty factor in roof framing, and without doubt the greatest tool in practical potency that ever was invented

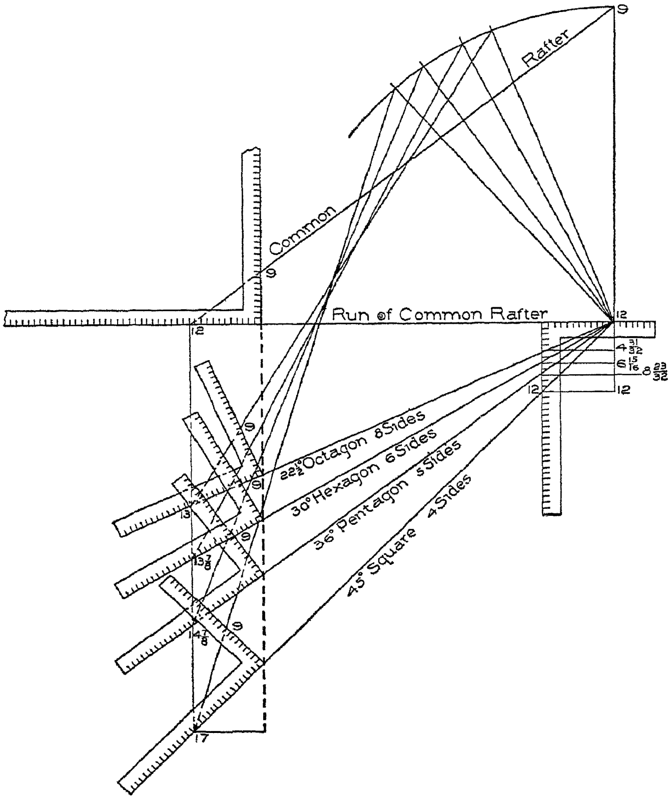


Fig. 12. Use of Square to Determine Length of Run for Rafters on Corners Other than 45°.

for the carpenter. With its use the lengths and bevels of every piece of timber that goes into the construction of the most intricate design of roof, can easily be obtained, and that with but very little knowledge of lines.

In roofs of equal pitch, as illustrated in Fig. 14, the steel square is all that is required if one properly understands how to handle it.

What is meant by a *pitch* of a roof, is the number of inches it rises to the foot of run.

In Fig. 15 is shown the steel square with figures representing the various pitches to the foot of run. For the $\frac{1}{2}$-pitch roof, the figures as shown, from 12 on tongue to 12 on blade, are those to be used on the steel square for the common rafter; and for $\frac{3}{8}$ pitch, the figures to be used on the square will be 12 and 9, as shown.

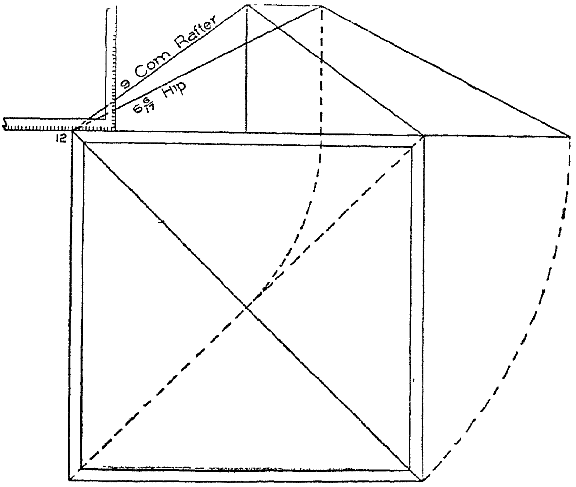


Fig. 13. Method of Finding Relative Height of Hip or Valley per Foot of Run to that of Common Rafter

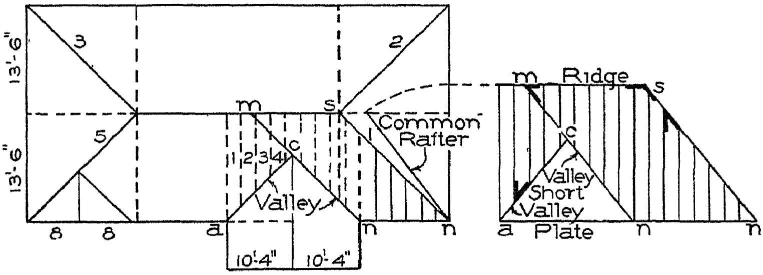


Fig. 14. Diagram to Illustrate Use of Steel Square in Laying Out Timbers of Roofs of Equal Pitch.

To understand this figure, it is necessary only to keep in mind that the pitch of a roof is reckoned from the span. Since the run in each pitch as shown is 12 inches, the span is two times 12 inches, which equals 24 inches; hence, 12 on blade to represent the foot run, and 12 on tongue to represent the rise over $\frac{1}{2}$ the span, will be the figures on the square for a $\frac{1}{2}$-pitch roof.

For the $\frac{3}{8}$ pitch, the figures are shown to be 12 on tongue and 9 on blade, 9 being $\frac{3}{8}$ of the span, 24 inches.

The same rule applies to all the pitches. The $\frac{1}{6}$ pitch is shown to rise 4 inches to the foot of run, because 4 inches is $\frac{1}{6}$ of the span, 24 inches, the $\frac{1}{3}$ pitch is shown to rise 8 inches to the foot of run, because 8 inches is $\frac{1}{3}$ of the span, 24 inches; etc.

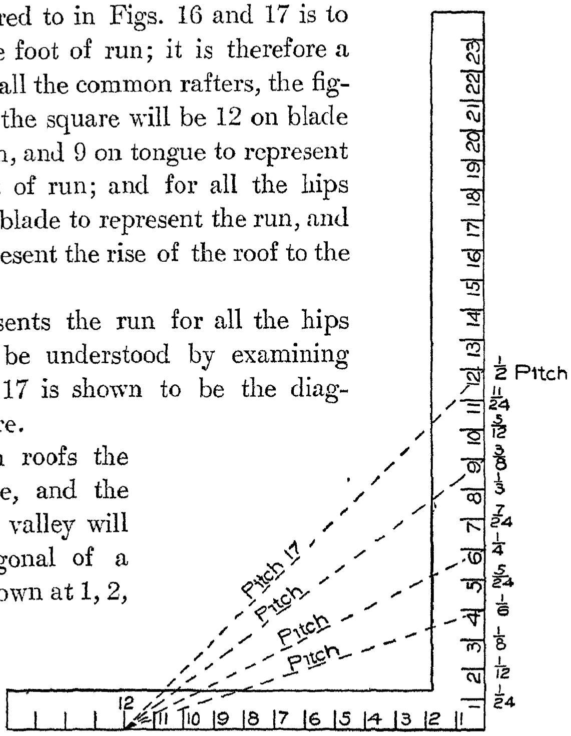


Fig. 15. Steel Square Giving Various Pitches to Foot of Run.

The roof referred to in Figs. 16 and 17 is to rise 9 inches to the foot of run; it is therefore a $\frac{3}{8}$-pitch roof. For all the common rafters, the figures to be used on the square will be 12 on blade to represent the run, and 9 on tongue to represent the rise to the foot of run; and for all the hips and valleys, 17 on blade to represent the run, and 9 on tongue to represent the rise of the roof to the foot of run.

Why 17 represents the run for all the hips and valleys, will be understood by examining Fig. 19, in which 17 is shown to be the diagonal of a foot square.

In equal-pitch roofs the corners are square, and the plan of the hip or valley will always be a diagonal of a square corner as shown at 1, 2, 3, and 5 in Fig. 14.

In Fig. 18 are shown $\frac{1}{6}$ pitch, $\frac{3}{8}$ pitch and $\frac{1}{2}$ pitch over a square corner. The figures to be used on the square for the hip, will be 17 for run in each case. For the $\frac{1}{6}$ pitch, the figures to be used would be 17 inches run and 4 inches rise, to correspond with the 12 inches run and 4 inches rise of the common rafter. For the $\frac{3}{8}$ pitch, the figures to be used for hip would be 17 inches run and 9 inches rise, to correspond with the 12 inches run and 9 inches rise of the common rafter; and for the ½ pitch, the figures to be used on the square will be 17 inches run and 12 inches rise, to correspond with the 12 inches run and 12 inches rise of the common rafter.

It will be observed from above, that in all cases where the plan of the hip or valley is a diagonal of a square, the figures to be used on the square for run will be 17 inches; and for the rise, whatever the roof rises to the foot of run. It should also be remembered that this is the condition in all roofs of equal pitch, where the angle of the hip or valley is a 45-degree angle, or, in other words, where we have the diagonal of a square.

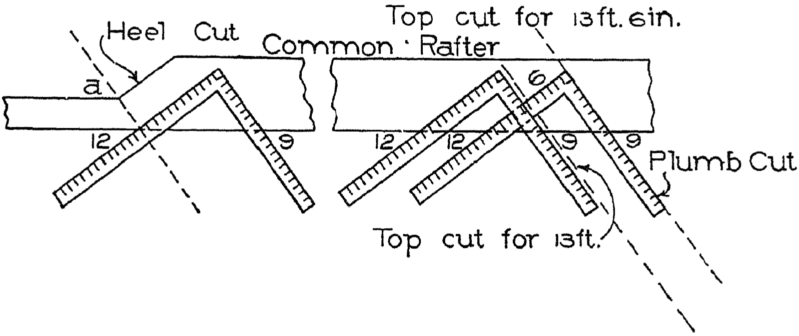


Fig 16 Method of Laying Out Common Rafters of a ⅜-Pitch Roof.

It has been shown in Fig. 12 how other figures for other plan angles may be found; and that in each case the figures for run vary according to the plan angle of the hip or valley, while the figure for the height in each case is similar.

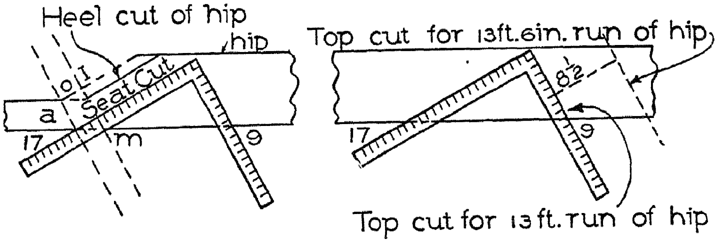

Heel cut of hip
hip
a
Seat Cut
17
m
9
Top cut for 13ft.6in. run of hip
17
9
Top cut for 13 ft. run of hip

Fig. 17. Method of Laying Out Hips and Valleys of a ⅜-Pitch Roof

In Fig. 14 are shown a variety of runs for common rafters, but all have the same pitch; they rise 9 inches to the foot of run. The main roof is shown to have a span of 27 feet, which makes the run of the common rafter 13 feet 6 inches. The run of the front wing is shown to be 10 feet 4 inches; and the run of the small gable at the left corner of the front, is shown to be 8 feet.

The diversity exhibited in the runs, and especially the fractional part of a foot shown in two of them, will afford an opportunity to treat of the main difficulties in laying out roof timbers in roofs of equal pitch. Let it be determined to have a rise of 9 inches to the foot of run; and in this connection it may be well to remember that the proportional rise to the foot run for roofs of equal pitch makes not the least difference in the method of treatment.

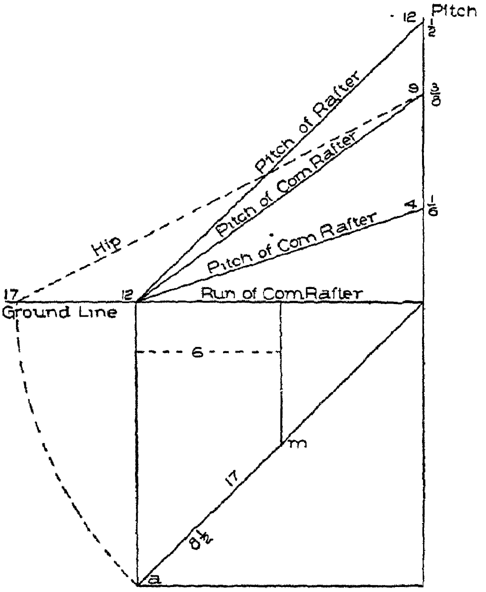


Fig. 18. Method of Laying Out Hips and Rafters for Roofs of Various Pitches over Square Corner.

To lay out the common rafters for the main roof, which has a run of 13 feet 6 inches, proceed as shown in Fig. 16.

Take 12 on the blade and 9 on the tongue, and step 13 times along the rafter timber. This will give the length of rafter for 13 feet of run. In this example, however, there is another 6 inches of run to cover. For this additional length, take 6 inches on the blade (it being ½ a foot run) for run, and take ½ of 9 on the tongue (which is 4½ inches), and step one time. This, in addition to what has already been found by stepping 13 times with 12 and 9, will give the full length of the rafter.

The square with 12 on blade and 9 on tongue will give the heel and plumb cuts.

Another method of finding the length of rafter for the 6 inches is shown in Fig. 16, where the square is shown applied to the rafter timber for the plumb cut. Square No. 1 is shown applied with 12 on blade and 9 on tongue for the length of the 13 feet. Square from this cut, measure 6 inches, the additional inches in the run; and to this point move the square, holding it on the side of the rafter timber with 12 on blade and 9 on tongue, as for a full foot run.

It will be observed that this method is easily adapted to find any fractional part of a foot in the length of rafters.

In the front gable, Fig. 14, the fractional part of a foot is 4 inches to be added to 10 feet of run; therefore, in that case, the line shown measured to 6 inches in Fig. 16 would measure only 4 inches for the front gable.

Heel Cut of Common Rafter. In Fig. 16 is also shown a method to lay out the heel cut of a common rafter. The square is shown applied with 12 on blade and 9 on tongue; and from where the 12 on the square intersects the edge of the rafter timber, a line is drawn square to the blade as shown by the dotted line from 12 to *a*. Then the thickness of the part of the rafter that is to project beyond the plate to hold the cornice, is gauged to intersect the dotted line at *a*; and from *a*, the heel cut is drawn with the square having 12 on blade and 9 on tongue, marking along the blade for the cut.

The common rafter for the front wing, which is shown to have a run of 10 feet 4 inches, is laid out precisely the same, except that for this rafter the square with 12 on blade and 9 on tongue will have to be stepped along the rafter timber only 10 times for the 10 feet of run; and for the fractional part of a foot (4 inches) which is in the run, either of the two methods already shown for the main rafter may be used.

The proportional figures to be used on the square for the 4 inches will be 4 on blade and 2¼ on tongue; and if the second method is used, make the addition to the length of rafter for 10 feet, by drawing a line 4 inches square from the tongue of square No. 1 (see Fig. 16), instead of 6 inches as there shown for the main rafter.

Hips. Three of the hips are shown in Fig. 14 to extend from the plate to the ridge-pole; they are marked in the figure as 1, 2, and 3 respectively, and are shown in plan to be diagonals of a square measuring 13 feet 6 inches by 13 feet 6 inches; they make an angle, therefore, of 45 degrees with the plate.

In Fig. 18 it has been shown that a hip standing at an angle of 45 degrees with the plate will have a run of 17 inches for every foot run of the common rafter. Therefore, to lay out the hips, the figures on the square will be 17 for run and 9 for rise; and by stepping 13 times along the hip rafter timber, the length of hip for 13 feet of run is obtained. The length for the additional 6 inches in the run may be found by squaring a distance of 8½ inches, as shown in Fig. 17, from the tongue of the square, and moving square No. 1 along the edge of the timber, holding the blade on 17 and tongue on 9, and marking the plumb cut where the dotted line is shown.

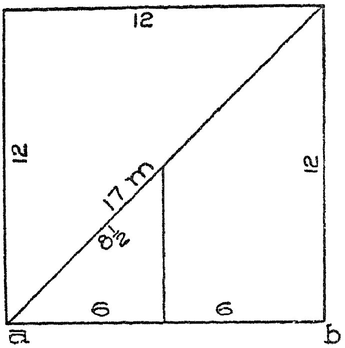


Fig 19. Diagram Showing Relative Lengths of Run for Hips and Common Rafters in Equal-Pitch Roofs.

In Fig. 18 is shown how to find the relative run length of a portion of a hip to correspond to that of a fractional part of a foot in the length of the common rafter. From 12 inches, measure along the run of the common rafter 6 inches, and drop a line to cut the diagonal line in *m*. From *m* to *a*, along the diagonal line, will be the relative run length of the part of hip to correspond with 6 inches run of the common rafter, and it measures 8½ inches.

The same results may be obtained by the following method of figuring:

As 12 : 17 : : 6
6
12)102
8 − 6 = 8½

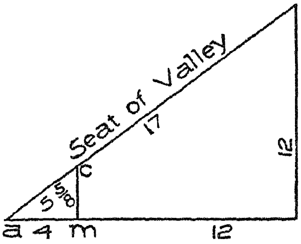


Fig 20 Method of Determining Run of Valley for Additional Run in Common Rafter.

In Fig. 19 is shown a 12-inch square, the diagonal *m* being 17 inches. By drawing lines from the base *a b* to cut the diagonal line, the part of the hip to correspond to that of the common rafter will be indicated on the line 17. In this figure it is shown that a 6-inch run on *a b*, which represents the run of a foot of a common rafter, will have a corresponding length of 8½ inches run on the line 17, which represents the plan line of the hip or valley in all equal-pitch roofs.

In the front gable, Fig. 14, it is shown that the run of the common rafter is 10 feet 4 inches. To find the length of the common rafter, take 12 on blade and 9 on tongue, and step 10 times along the rafter timber; and for the fractional part of a foot (4 inches), proceed as was shown in Fig. 16 for the rafter of the main roof; but in this case measure out square to the tongue of square No. 1, 4 inches instead of 6 inches.

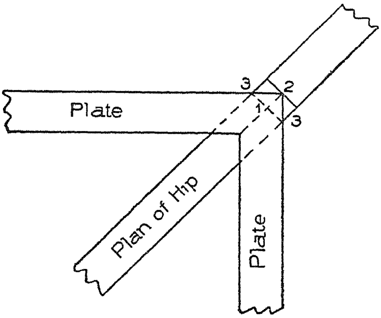


Fig. 21. Corner of Square Building, Showing Plan Lines of Plates and Hip

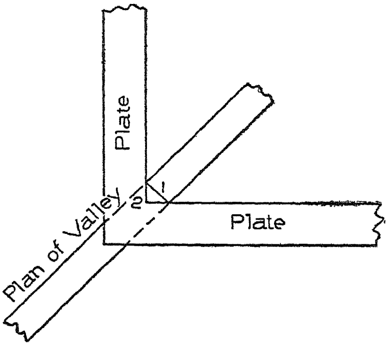


Fig. 22 Corner of Square Building, Showing Plan Lines of Plates and Valley.

The additional length for the fractional 4 inches run can also be found by taking 4 inches on blade and 3 inches on tongue of square, and stepping one time; this, in addition to the length obtained by stepping 10 times along the rafter timber with 12 on blade and 9 on tongue, will give the full length of the rafter for a run of 10 feet 4 inches.

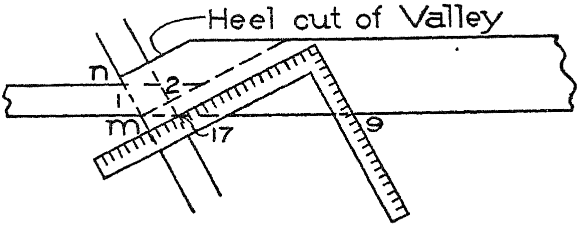


Fig. 23. Use of Square to Determine Heel Cut of Valley.

In the intersection of this roof with the main roof, there are shown to be two valleys of different lengths. The long one extends from the plate at *n* (Fig. 14) to the ridge of the main roof at *m*; it has therefore a run of 13 feet 6 inches. For the length, proceed as for the hips, by taking 17 on blade of the square and 9 on tongue, and stepping 13 times for the length of the 13 feet; and for the fractional 6 inches, proceed precisely as shown in Fig. 17 for the hip, by squaring out from the tongue of square No. 1, 8½ inches; this, in addition to the length obtained for the 13 feet, will give the full length of the long valley *n m*.

The length of the short valley *a c*, as shown, extends over the run of 10 feet 4 inches, and butts against the side of the long valley at *c* By taking 17 on blade and 9 on tongue, and stepping along the rafter timber 10 times, the length for the 10 feet is found; and for the 4 inches, measure 5⅝ inches square from the tongue of square No. 1, in the manner shown in Fig. 17, where the 8½ inches is shown added for the 6 inches additional run of the main roof for the hips.

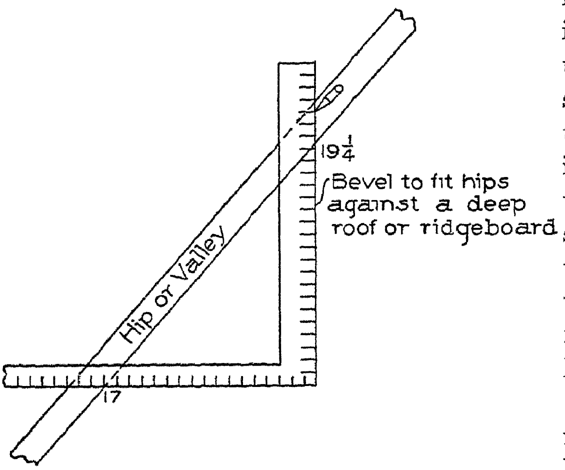


Fig. 24 Steel Square Applied to Finding Bevel for Fitting Top of Hip or Valley to Ridge.

The length 5⅝ is found as shown in Fig. 20, by measuring 4 inches from *a* to *m* along the run of common rafter for one foot. Upon *m* erect a line to cut the seat of the valley at *c*; from *c* to *a* will be the run of the valley to correspond with 4 inches run of the common rafter, and it will measure 5⅝ inches.

How to Treat the Heel Cut of Hips and Valleys. Having found the lengths of the hips and valleys to correspond to the common rafters, it will be necessary to find also the thickness of each above the plate to correspond to the thickness the common rafter will be above the plate.

In Fig. 21 is shown a corner of a square building, showing the plates and the plan lines of a hip. The length of the hip, as already found, will cover the span from the ridge to the corner 2; but the sides of the hip intersect the plates at 3 and 3 respectively; therefore the distance from 2 to 1, as shown in this diagram, is measured backwards from *a* to 1 in the manner shown in Fig. 17; then a plumb line is drawn through 1 to *m*, parallel to the plumb cut *a*-17. From *m* to *o* on this line, measure the same thickness as that of the common rafter; and through *o* draw the heel cut to *a* as shown.

In like manner the thickness of the valley above the plate is found; but as the valley as shown in the plan figure, Fig. 22, projects beyond point 2 before it intersects the outside of the plates, the distance from 2 to 1 in the case of the valley will have to be measured outwards from 2, as shown from 2 to 1 in Fig. 23; and at the point thus found the thickness of the valley is to be measured to correspond with that of the common rafter as shown at *m n*.

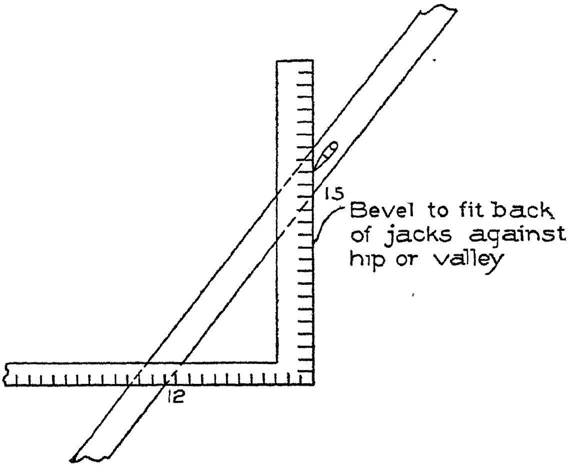


Fig. 25 Steel Square Applied to Jack Rafter to Find Bevel for Fitting against Side of Hip or Valley.

In Fig. 24 is shown the steel square applied to a hip or valley timber to cut the bevel that will fit the top end against the ridge. The figures on the square are 17 and 19¼. The 17 represents the length of the plan line of the hip or valley for a foot of run, which, as was shown in previous figures, will always be 17 inches in roofs of equal pitch, where the plan lines stand at 45 degrees to the plates and square to each other.

The 19¼ taken on the blade represents the actual length of a hip or valley that will span over a run of 17 inches. The bevel is marked along the blade.

The cut across the back of the short valley to fit it against the side of the long valley, will be a square cut owing to the two plan lines being at right angles to each other.

In Fig. 25 is shown the steel square applied to a jack rafter to cut the back bevel, to fit it against the side of a hip or valley. The figures on the square are 12 on tongue and 15 on blade, the 12 representing a foot run of a common rafter, and the 15 the length of a rafter that will span over a foot run; marking along the blade will give the bevel.

The rule in every case to find the back bevel for jacks in roofs of equal pitch, is to take 12 on the tongue to represent the foot run, and the length of the rafter for a foot of run on the blade, marking along the blade in each case for the bevel.

In a ½-pitch roof, which is the most common in all parts of the country, the length of rafter for a foot of run will be 17 inches; hence it will be well to remember that 12 on tongue and 17 on blade, marking along the blade, will give the bevel to fit a jack against a hip or a valley in a ½-pitch roof.

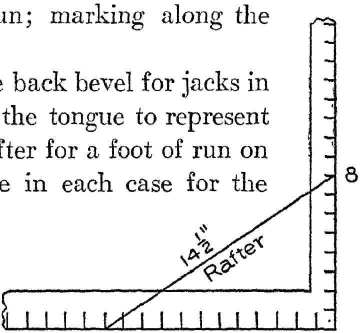


Fig. 26 Finding Length to Shorten Rafters for Jacks per Foot of Run.

In a roof having a rise of 9 inches to the foot of run, such as the one under consideration, the length of rafter for one foot of run will be 15 inches. The square as shown in Fig. 25, with 12 on tongue and 15 on blade, will give the bevel by marking along the blade.

To find the length of a rafter for a foot of run for any other pitch, place the two-foot rule diagonally from 12 on the blade of the square to the figure on tongue representing the rise of the roof to the foot of run; the rule will give the length of the rafter that will span over one foot of run.

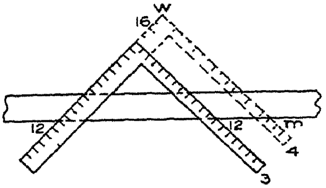


Fig. 27 Finding Length of Jack Rafter in ½-Pitch Roof.

The length of rafter for a foot of run will also determine the difference in lengths of jacks. For example, if a roof rises 12 inches to one foot of run, the rafter over this span has been found to be 17 inches; this, therefore, is the number of inches each jack is shortened in one foot of run. If the rise of the roof is 8 inches to the foot of run, the length of the rafter is found for one foot of run, by placing the rule diagonally from 12 on tongue to 8 on blade, which gives $14\frac{1}{2}$ inches, as shown in Fig. 26. This, therefore, will be the number of inches the jacks are to be shortened in a roof rising 8 inches to the foot of run. If the jacks are placed 24 inches from center to center, then multiply $14\frac{1}{2}$ by $2 = 29$ inches.

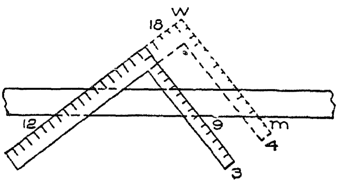


Fig 28 Finding Length of Jack Rafter in $\frac{3}{8}$-Pitch Roof.

In Fig. 27 is shown how to find the length with the steel square. The square is placed on the jack timber rafter with the figures that have been used to cut the common rafter. In Fig. 27, 12 on blade and 12 on tongue were the figures used to cut the common rafter, the roof being $\frac{1}{2}$ pitch, rising 12 inches to the foot of run. In the diagram it is shown how to find the length of a jack rafter if placed 16 inches from center to center. The method is to move the square as shown along the line of the blade until the blade measures 16 inches; the tongue then would be as shown from *w* to *m*, and the length of the jack would be from 12 on blade to *m* on tongue, on the edge of the jack rafter timber as shown.

This latter method becomes convenient when the space between jacks is less than 18 inches; but if used when the space is more than 18 inches it will become necessary to use two squares; otherwise the tongue as shown at *m* would not reach the edge of the timber.

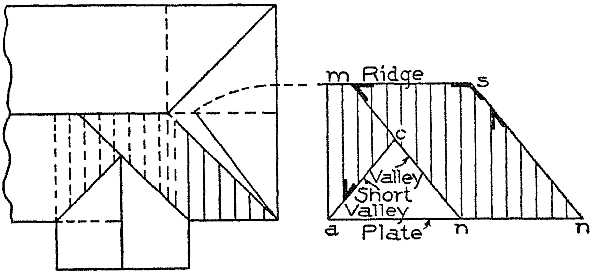


Fig. 29. Method of Determining Length of Jacks Between Hips and Valleys; also Bevels for Jacks, Hips, and Valleys.

In Fig. 28 the same method is shown for finding the length of a jack rafter for a roof rising 9 inches to the foot of run, with the jacks placed 18 inches center to center. The square in this diagram is shown placed on the jack rafter timber with 12 on blade and 9 on tongue; then it is moved forward along the line of the blade to *w*. The blade, when in this latter position, will measure 18 inches. The tongue will meet the edge of the timber at *m*, and the distance from *m* on tongue to 12 on blade will indicate the length of a jack, or, in other words, will show the length each jack is shortened when placed 18 inches between centers in a roof having a pitch of 9 inches to the foot of run.

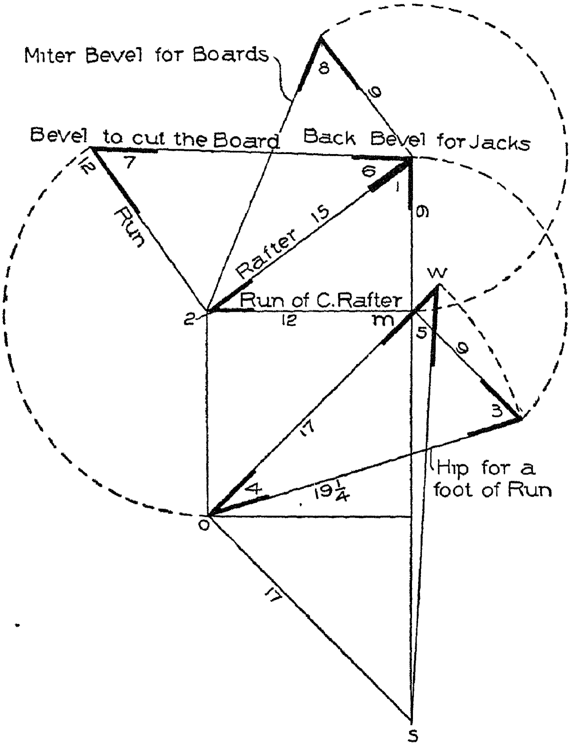


Fig. 30. Method of Finding Bevels for All Timbers in Roofs of Equal Pitch.

When jacks are placed between hips and valleys as shown at 1, 2, 3, 4, etc., in Fig. 14, a better method of treatment is shown in Fig. 29, where the slope of the roof is projected into the horizontal plane. The distance from the plate in this figure to the ridge *m*, equals the length of the common rafter for the main roof. On the plate *a n n* is made equal to *a n n* in Fig. 14. By drawing a figure like this to a scale of one inch to one foot, the length of all the jacks can be measured and also the lengths of the hip and the two valleys. It also gives the bevels for the jacks, as well as the bevel to fit the hip and valley against the ridge; but this last bevel must be applied to the hip and valley when backed.

It has been shown before, that the figures to be used on the square for this bevel when the timber is left square on back as is the custom in construction, are the length of a foot run of a hip or valley, which is 17, on tongue, and the length of a hip or valley that will span over 17 inches run, on blade—the blade giving the bevel.

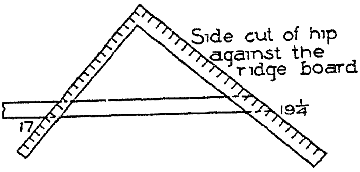


Fig 31 Method of Finding Bevel 5, Fig 30, for Fitting Hip or Valley Against Ridge when not Backed.

Fig. 30 contains all the bevels or cuts that have been treated upon so far, and, if correctly understood, will enable any one to frame any roof of equal pitch. In this figure it is shown that 12 inches run and 9 inches rise will give bevels 1 and 2, which are the plumb and heel cuts of rafters of a roof rising 9 inches to the foot of run. By taking these figures, therefore, on the square, 9 inches on the tongue and 12 inches on the blade, marking along the tongue will give the plumb cut, and marking along the blade will give the heel cut.

Bevels 3 and 4 are the plumb and heel cuts for the hip, and are shown to have the length of the seat of hip for one foot run, which is 17 inches. By taking 17 inches, therefore, on the blade, and 9 inches on the tongue, marking along the tongue for the plumb cut, and along the blade for the heel cut, the plumb and heel cuts are found. Bevel 5, which is to fit the hip or valley against the ridge when not backed, is shown from *o w*, the length of the hip for one foot of run, which is 19¼ inches, and from *o s*, which always in roofs of equal pitch will be 17 inches and equal in length to the seat of a hip or valley for one foot of run.

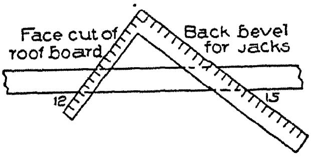


Fig. 32. Method of Finding Back Bevel 6, Fig 30, for Jack Rafters, and Bevel 7, for Roof-Board.

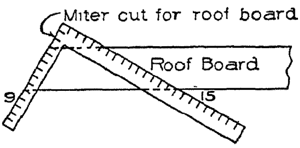


Fig 33. Determining Miter Cut for Roof-Board

These figures, therefore, taken on the square, 19¼ on the blade, and 17 on the tongue, will give the bevel by marking along the blade as shown in Fig. 31, where the square is shown applied to the hip timber with 19¼ on blade and 17 on tongue, the blade showing the cut.

Bevels 6 and 7 in Fig. 30 are shown formed of the length of the rafter for one foot of run, which is 15 inches, and the run of the rafter, which is 12 inches. These figures are applied on the square, as shown in Fig. 32, to a jack rafter timber; taking 15 on the blade and 12 on the tongue, marking along the blade will give the back bevel for the jack rafters, and marking along the tongue will give the face cut of roof-boards to fit along the hip or valley.

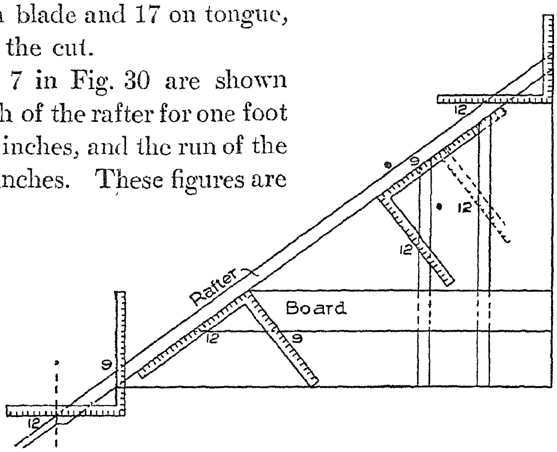


Fig 34. Laying Out Timbers of One-half Gable of ⅜-Pitch Roof.

It is shown in Fig. 30, also, that by taking the length of rafter 15 inches on blade, and rise of roof 9 inches on tongue, bevel 8 will give the miter cut for the roof-boards.

In Fig. 33 the square is shown applied to a roof-board with 15 on blade, which is the length of the rafter to one foot of run, and with 9 on tongue, which is the rise of the roof to the foot run; marking along the tongue will give the miter for the boards.

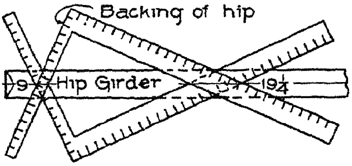


Fig. 35. Finding Backing of Hip in Gable Roof.

Other uses may be made of these figures, as shown in Fig. 34, which is one-half of a gable of a roof rising 9 inches to the foot run. The squares at the bottom and the top will give the plumb and heel cuts of the common rafter. The same figures on the square applied to the studding, marking along the tongue for the cut, will give the bevel to fit the studding against the rafter; and by marking along the blade we obtain the cut for the boards that run across the gable. By taking 19¼ on blade, which is the length of the hip for one foot of run, and taking on the tongue the rise of the roof to the foot of run, which is 9 inches, and applying these as shown in Fig. 35, we obtain the backing of the hip by marking along the tongue of the two squares, as shown.

It will be observed from what has been said, that in roofs of equal pitch the figure 12 on the blade, and whatever number of inches the roof rises to the foot run on the tongue, will give the plumb and heel cuts for the common rafter; and that by taking 17 on the blade instead of 12, and taking on the tongue the figure representing the rise of the roof to the foot run, the plumb and heel cuts are found for the hips and valleys.

By taking the length of the common rafter for one foot of run on blade, and the run 12 on tongue, marking along the blade will give the back bevel for the jack to fit the hip or valley, and marking along the tongue will give the bevel to cut the roof-boards to fit the line of hip or valley upon the roof.

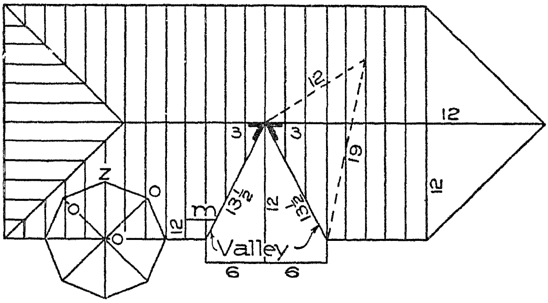


Fig 36. Laying Out Timbers of Roof with Two Unequal Pitches.

With this knowledge of what figures to use, and why they are used, it will be an easy matter for anyone to lay out all rafters for equal-pitch roofs.

In Fig. 36 is shown a plan of a roof with two unequal pitches. The main roof is shown to have a rise of 12 inches to the foot run. The front wing is shown to have a run of 6 feet and to rise 12 feet; it has thus a pitch of 24 inches to the foot run. Therefore 12 on blade of the square and 12 on tongue will give the plumb and heel cuts for the main roof, and by stepping 12 times along the rafter timber the length of the rafter is found. The figures on the square to find the heel and plumb cuts for the rafter in the front wing, will be 12 run and 24 rise, and by stepping 6 times (the number of feet in the run of the rafter), the length will be found over the run of 6 feet, and it will measure 13 feet 6 inches.

If, in place of stepping along the timber, the diagonal of 12 and 24 is multiplied by 6, the number of feet in the run, the length may be found even to a greater exactitude.

Many carpenters use this method of framing; and to those who have confidence in their ability to figure correctly, it is a saving of time, and, as before said, will result in a more accurate measurement; but the better and more scientific method of framing is to work to a scale of one inch, as has already been explained.

According to that method, the diagonal of a foot of run, and the number of inches to the foot run the roof is rising, measured to a scale, will give the exact length. For example, the main roof in Fig. 36 is rising 12 inches to a foot of run. The diagonal of 12 and 12 is 17 inches, which, considered as a scale of one inch to a foot, will give 17 feet, and this will be the exact length of the rafter for a roof rising 12 inches to the foot run and having a run of 12 feet.

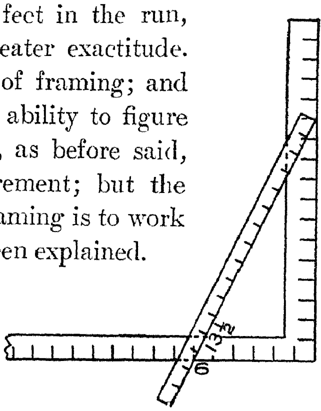


Fig 37. Finding Length of Rafter for Front Wing in Roof Shown in Fig. 36.

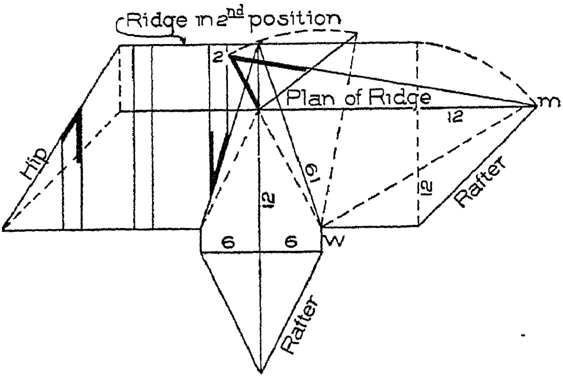


Fig 38. Laying Out Timbers of Roof Shown in Fig 36, by Projecting Slope of Roof into Horizontal Plane.

The length of the rafter for the front wing, which has a run of 6 feet and a rise of 12 feet, may be obtained by placing the rule as shown in Fig. 37, from 6 on blade to 12 on tongue, which will give a length of 13½ inches. If the scale be considered as one inch to a foot, this will equal 13 feet 6 inches, which will be the exact length of a common rafter rising 24 inches to the foot run and having a run of 6 feet.

It will be observed that the plan lines of the valleys in this figure in respect to one another deviate from forming a right angle. In equal-pitch roofs the plan lines are always at right angles to each other, and therefore the diagonal of 12 and 12, which is 17 inches, will be the relative foot run of valleys and hips in equal-pitch roofs.

In Fig. 36 is shown how to find the figures to use on the square for valleys and hips when deviating from the right angle. A line is drawn at a distance of 12 inches from the plate and parallel to it, cutting the valley in *m* as shown. The part of the valley from *m* to the plate will measure 13½ inches, which is the figure that is to be used on the square to obtain the length and cuts of the valleys.

It will be observed that this equals the length of the common rafter as found by the square and rule in Fig. 37. In that figure is shown 12 on tongue and 6 on blade. The 12 here represents the rise, and the 6 the run of the front roof. If the 12 be taken to represent the run of the main roof, and the 6 to represent the run of the front roof, then, the diagonal 13½ will indicate the length of the seat of the valley for 12 feet of run, and therefore for one foot it will be 13½ inches. Now, by taking 13½ on the blade for run, and 12 inches on the tongue for rise, and stepping along the valley rafter timber 12 times, the length of the valley will be found. The blade will give the heel cut, and the tongue the plumb cut.

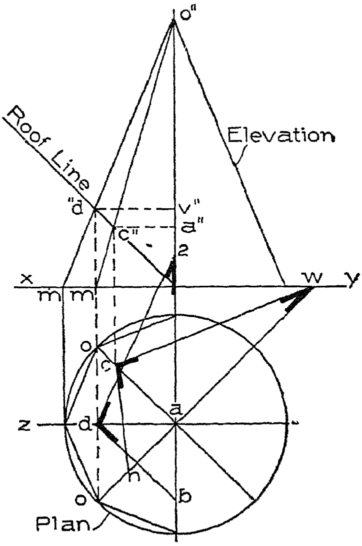


Fig 39 Method of Finding Length and Cuts of Octagon Hips Intersecting a Roof.

In Fig. 38 is shown the slope of the roof projected into the horizontal plane. By drawing a figure based on a scale of one inch to one foot, all the timbers on the slope of the roof can be measured. Bevel 2, shown in this figure, is to fit the valleys against the ridge. By drawing a line from *w* square to the seat of the valley to *m*, making

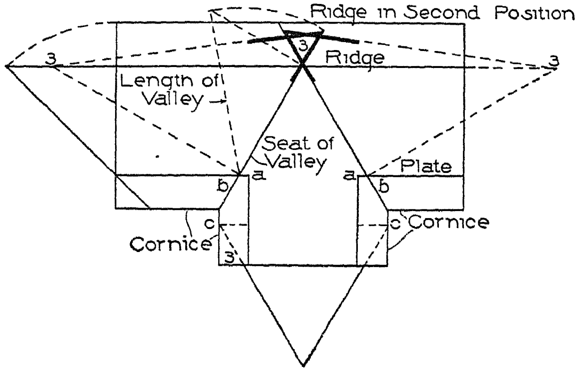


Fig. 40. Showing How Cornice Affects Valleys and Plates in Roof with Unequal Pitches.

w 2 equal in length to the length of the valley, as shown, and by connecting 2 and *m*, the bevel at 2 is found, which will fit the valleys against the ridge, as shown at 3 and 3 in Fig. 36.

In Fig. 39, is shown how to find the length and cuts of octagon hips intersecting a roof. In Fig. 36, half the plan of the octagon is shown to be inside of the plate, and the hips *o, z, o* intersect the slope of the roof. In Fig. 39, the lines below *x y* are the plan lines; and those above, the elevation. From *z, o o*, in the plan, draw lines to *x y*, as shown from *o* to *m* and from *z* to *m*; from *m* and *m*, draw the elevation lines to the apex *o''*, intersecting the line of the roof in *d''* and *c''*. From *d''* and *c''*, draw the lines *d'' v''* and *c'' a''* parallel to *x y*; from *c''*, drop a line to intersect the plan line *a o* in *c*. Make *a w* equal in length to *a'' o''* of the elevation, and connect *w c*; measure from *w* to *n* the full height of the octagon as shown from *x y* to the apex *o''*; and connect *c n*. The length from *w* to *c* is that of

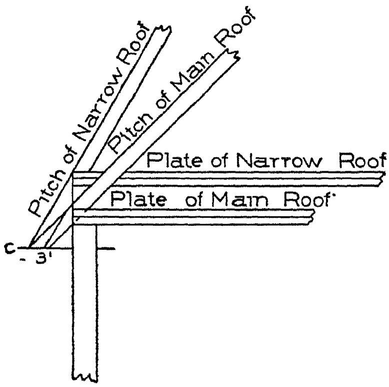


Fig. 41. Showing Relative Position of Plates in Roof with Two Unequal Pitches.

the two hips shown at *o o* in Fig. 36, both being equal hips intersecting the roof at an equal distance from the plate. The bevel at *w* is the top bevel, and the bevel at *c* will fit the roof.

Again, drop a line from *d″* to intersect the plan line *a z* in *d*. Make *a* 2 equal to *v″ o″* in the elevation, and connect 2 *d*. Measure from 2 to *b* the full height of the tower as shown from *x y* to the apex *o″* in the elevation, and connect *d b*. The length 2 *d* represents the length of the hip *z* shown in Fig. 36; the bevel at 2 is that of the top; and the bevel at *d*, the one that will fit the foot of the hip to the intersecting roof.

When a cornice of any considerable width runs around a roof of this kind, it affects the plates and the angle of the valleys as shown in Fig. 40. In this figure are shown the same valleys as in Fig. 36; but, owing to the width of the cornice, the foot of each has been moved the distance *a b* along the plate of the main roof. Why this is done is shown in the drawing to be caused by the necessity for the valleys to intersect the corners *c c* of the cornice.

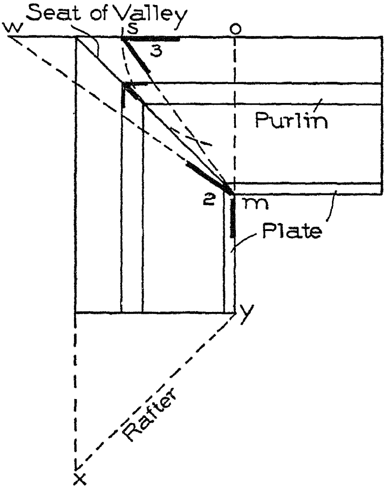


Fig. 42. Method of Finding Bevels for Purlins in Equal-Pitch Roofs

The plates are also affected as shown in Fig. 41, where the plate of the narrow roof is shown to be much higher than the plate of the main roof.

The bevels shown at 3, Fig. 40, are to fit the valleys against the ridge.

In Fig. 42 is shown a very simple method of finding the bevels for purlins in equal-pitch roofs. Draw the plan of the corner as shown, and a line from *m* to *o*; measure from *o* the length *x y*, representing the common rafter, to *w*; from *w* draw a line to *m*; the bevel shown at 2 will fit the top face of the purlin. Again, from *o*, describe an arc to cut the seat of the valley, and continue same around to *S*; connect *S m*; the bevel at 3 will be the side bevel.

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are examples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for College, Civil Service, or Engineer's License. In some cases numerical answers are given as a further aid in this work.

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY.

PART I.

---

1. Give a rule for squaring a log to get the strongest possible timber out of it.

2. What is the "three-four-five rule," and how is it used?

3. Describe (and illustrate by a sketch) a splice suitable for a piece subjected to a bending stress.

4. Why is a "ledger-board" not as good as a "girt" for supporting the ends of floor joists?

5. What are partition caps and soles? What takes the place of the sole when there is a partition directly beneath the one which is being built?

6. Show by a sketch what is meant by "sizing down" a joist onto a girder or sill.

7. What is the method employed for supporting a corner which has no direct support beneath it? Make a sketch of the framing for such a corner.

8. From what two classes of trees is most building lumber obtained?

9. Give a brief description of the following varieties of timber:

a. Cypress
b. Ash
c. Poplar
d. Spruce
e. Pine
f. Oak

10. Name, and show by sketch, five kinds of joints used in carpentry.

11. What must take place before a "fished" splice for tension can be pulled apart?

12. What is a "raised girt?" a "dropped girt?"

13. How are furring walls around chimney breasts constructed?

14. Explain one method of framing joists into girders. Girders into sills. Illustrate with sketch.

15. How are floors "bridged?" Which is the best method? Why?

16. What is the manner of growth of the trees named in Question 9, and in what other way do trees grow?

17. What qualities are required in a wood to be used for light framing?

18. What is "ground water," and why must it be taken into account in the laying out of a building?

19. Show by sketch how the corner of a wooden building may be framed so as to give a nailing for the lathing.

20. At the point where a partition meets an outside wall, what should be the arrangement of the studding? Why?

21. Explain the method of framing around an opening in the floor frame for a chimney or staircase.

22. Give clear definitions of the following:

a. Pith
b. Annual Ring
c. Medullary Ray
d. Heartshake
e. Heartwood
f. Sapwood
g. Cross-grained Timber
h. Cupshake and Windshake

23. What is the "heel" of a steel square? the "blade?" the "tongue?"

24. What are "batter-boards?" Make a sketch of one form of batter-board.

25. How is a "key" employed in a splice for tension? What determines the distance between keys if there are more than one in a single splice?

26. What is the function of the braces in braced frames? Show by a sketch one method of bracing a frame.

27. What is meant by "crowning?" Why is it necessary?

28. Explain the effect of the shrinkage of framing timber, and explain how unequal settlement (due to such shrinkage) may be prevented.

29. What is the best method of cutting planks from a log? Why?

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY.

PART II.

1. Give full description of the various forms of roofs, with sketches.

2. Give a rule for obtaining the rise of the rafter in a roof, the span of which is known.

3. Describe the method employed in framing a gambrel roof.

4. What is the "run of a rafter"? What is the rise? What is meant by the pitch?

5. What important property is characteristic of all lines in a roof surface which are parallel to the ridge line? Tell in a general way how this fact is made use of in laying out the valley line.

6. What are the two distances which determine the position of the steel square in laying out valley rafters?

7. What is the principle used in finding the slope of the hip rafter in an "ogee" roof?

8. What is the usual size of rafters for ordinary frame dwellings?

9. Describe a hip rafter. What relation does it bear to a parallel valley rafter in the same roof surface?

10. What is the method of framing adopted for the valley when a small gable intersects a large roof?

11. Describe the different kinds of jack rafters.

12. What must be done to studs forming the framework of an attic partition in order to make them fit the under side of the roof framing?

13. In what does "backing" consist?

14. Describe two methods of forming the eaves on frame buildings

15. Describe the framing of a mansard roof.

16. What is the purpose of the ridge-pole and how is it usually made.

17. Describe two different kinds of dormer windows.

18. How are openings made in a roof frame for dormer windows, skylights, etc.?

19. When are trussed partitions used? Describe in a general way their construction.

20. Describe two methods of constructing an "inclined floor".

21. What is the difference between a "king-post trussed beam" and a "queen-post trussed beam"?

22. Describe the construction of a "flitch plate girder".

23. What are the different kinds of rafters used in a roof frame? Describe each.

24. Give a rule for determining the general proportions of a gambrel roof. Illustrate by a sketch.

25. How are rafters of long span strengthened? What are "dwarf walls"? What is a collar beam? Make sketches of same.

26. Describe the construction of a "notched" beam. A "keyed" beam.

27. Explain the difference between a "king-post truss" and a "queen-post truss".

28. How is the curved form given to a bell-shaped or concave tower roof?

29. Is the stress in the king-post of a common king-post truss tension or compression? Of what material is it ordinarily made?

30. Describe or show by a sketch a method of framing a domical roof with provision for a lantern at the top.

31. What is a "groined" ceiling?

32. How far may a balcony or gallery be allowed to project beyond the line of supporting columns without the introduction of a brace?

33. What is the difference between the two connections shown in Fig. 202? What does each depend upon for its strength?

REVIEW QUESTIONS

ON THE SUBJECT OF

STAIR-BUILDING

1. Define *staircase* and *stairway.*

2. What is meant by the *rise* and *run* of a stairway? How measured?

3. Define *tread* and *riser.*

4. How do treads and risers compare as to number? Why?

5. What is a *string* or *string-board*? Describe the various kinds of strings.

6. How are treads and risers fitted together and fastened in housed strings?

7. Describe the construction and use of a *pitch-board.*

8. How are the relative dimensions of treads and risers determined?

9. Are all the risers in a flight of stairs cut of uniform height?

10. Describe the use of *flyers, winders,* and *dancing steps.*

11. How are balusters fastened on strings?

12. How are strings fastened to newel-posts?

13. Describe methods of constructing *bullnose steps* and risers for same.

14. What is the difference between a *quarter-space landing* and a *half-space landing*?

15. Define the terms: *well-hole*; *drum*; *cylinder*; *kerfing*; *geometrical stairway*; *carriage timber*; *wreath*; *tangent*; *crown tangent*; *springing of a well-hole*; *ground-line*; *swan-neck*; *face-mould*; *nosing*; *return nosing*; *spandrel*; *cove-moulding.*

16. Describe the use of the *face-mould.*

17. When the face-mould is applied, and material for the wreath cut from the plank, how is the wreath-piece given its final shape?

18. What is the use of *tangents* in handrailing? What do the *bevels* represent?

19. What is an *oblique plane*?

20. Are all wreaths assumed to be resting on an oblique plane?

21. In referring to an oblique plane, what do you understand by the expressions *inclined in one direction only* and *inclined in two directions*?

22. What is meant when two wreath tangents are said to be *equally inclined*? What, when *unequally inclined*?

23. When an oblique plane is inclined in one direction only, how many bevels will be needed to twist the wreath?

24. When the plane inclines in two directions, how many bevels are required?

25. When the inclination is equal in two directions, how many bevels are needed?

26. When the plane is unequally inclined in two directions, how many bevels are needed?

27. How can a stairway be reinforced?

28. How should a scroll bracket be terminated against the riser?

29. When a plane is equally inclined in two directions, how are the bevel or bevels to be applied to twist the wreath resting upon it in its ascent around the well-hole?

30. What is the difference between the *plan tangents, pitch-line of tangents,* and *tangents of the face-mould*?

31. Why is it necessary to determine with exactness the angle between the tangents on the face-mould?

32. What is the width of the face-mould to be, when laid out on the minor axis?

33. How is the width of the mould at the ends determined?

34. How do you find the *minor axis* and *major axis* of the mould curves?

35. Show how to find the thickness of the plank that will be required for the wreath.

36. When the plan tangents are at a right angle to each other, and the pitch is equal, how are the bevels to be applied, (1) in relation to each other; (2) in relation to the sides of the wreath?

REVIEW QUESTIONS

ON THE SUBJECT OF

ESTIMATING.

PART I

---

1. (a) What will a walk of bluestone flagging 4 ft. wide and 19 ft. long cost, complete? (b) Give cost of limestone coping for an 18-inch wall on one side of the path.

2. (a) About how many square yards of surface will four pounds of paint cover in two coats? (b) How much will it cost to paint a brick wall 8 ft. high and 15 ft. long with three coats of paint?

3. (a) How many feet B. M. in a 4-in. x 10-in. stick 22 ft. long? (b) How much lumber will it take to stud up a wall 12 ft. long and 9 ft. high with two windows in it?

4. Give an analysis of one cubic yard of concrete.

5. What percentage of the cost of a building should be allowed for heating by furnace? How much of this goes to the labor?

6. What will a square of slating cost?

7. Analyze the cost of a square of flooring.

8. (a) What will be the cost of a plain copper roof for a store 30 ft. x 40 ft.? (b) What will be the cost of a tin roof?

9. How many cubic feet of wall will a thousand bricks lay?

10. Give an analysis of the cost of 100 square yards of 2-coat plastering.

11. What special data besides plans and specifications are necessary to figure a job for a contract?

12. How many square feet will 1000 shingles lay at 5 in. to the weather?

13. What will be the approximate cost of a house 20 ft. × 30 ft. with an 8 ft. cellar and a half-pitch gable roof, at 12 cents per cubic foot?

14. How large a furnace pipe must be run to a room 15 ft × 20 ft. and 10 ft. high, and what will be the size of register?

15. Give a rule for finding the number of studs in a front if set 16 in. on centers. If set 12 in. on centers.

16. What will be the cost of an ordinary flight of stairs of 17 risers for a $3000 house? How much should be allowed for the cellar stairs of 14 risers?

17. How much studding can two men set in one day? How much boarding? Shingles? Diagonal boarding?

18. (a) How many square yards of 2-coat plastering can a mason and helper put on in one day? (b) What will it cost?

19. (a) What will the newel of an ordinary staircase cost? (b) How much will the balusters of first run cost at two to a tread if the run is 8 risers high?

20. (a) How many bricks will be required to build a wall 10 ft. high, 30 ft. long, and 1 ft. thick. (b) What will it cost in 1 to 3 lime mortar?

21. What will it cost to put on 1000 laths?

22. In making repairs a man required the services of a carpenter for 5 hours, a plumber and helper 2 days, and an electrician for a day and a half, what was his bill for labor?

23. What will it cost to dig out a cellar 18 ft. × 30 ft.; 4 ft. below grade at one end and 6 ft. the other?

24. (a) At a base price of $2.45 per cwt. what will three cwt. of 6-penny box nails cost? (b) What will 1 cwt. of 4-penny slating nails cost?

25. (a) What per cent of the cost of a house will usually go to the plumbing? (b) What portion of this will represent the labor?

26. (a) What is the relative cost of marble as compared with limestone? (b) Of sandstone as compared with limestone?

27. (a) What is the usual cost of moulded finish in white wood or cypress? (b) What will the casings for both sides of a door 3 ft × 7 ft. cost, using a 5-inch casing with corner blocks?

28. (a) About how many cubic feet will one square foot of direct steam radiation heat, in the first story of a dwelling? (b) Direct hot water radiation?

29. What will be the area of a pyramidal roof 20 ft. square at the base and 15 ft. on the rafter line?

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